SPECIAL ISSUE! RARE APOLLO PHOTO COLLECTION

FINAL FRONTIER

The Magazine of Space Exploration

August 1989

It was 20 years ago today.



PLUS!

THE MOON IN 2009

VOYAGER MEETS NEPTUNE

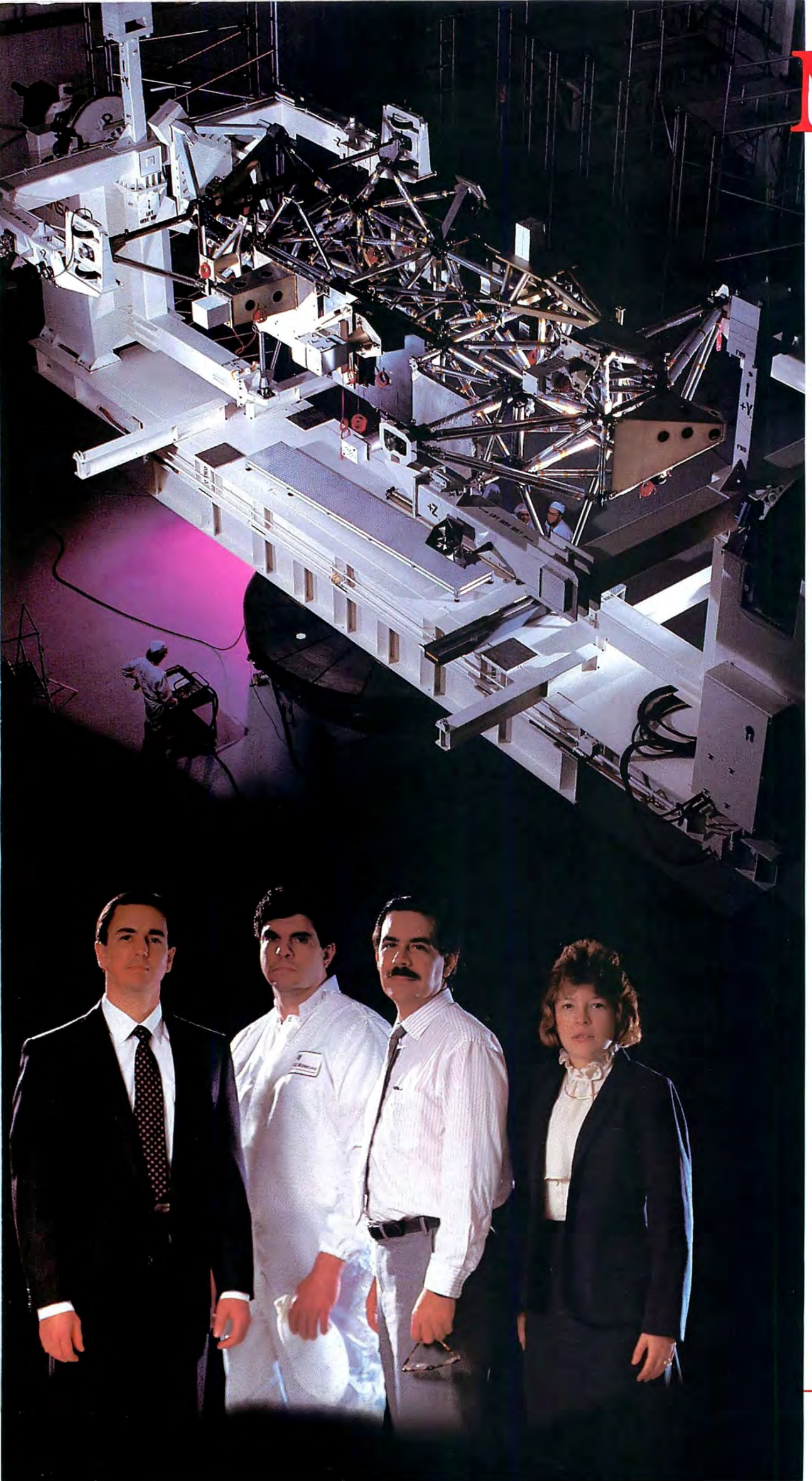
SPACE VISIONARIES OF THE 1950'S

USA $3.50/OTHER $4.50

08

0 14302 73813 4

DISPLAY UNTIL 8/31/89



Mission.

When a spacecraft like NASA's Upper Atmosphere Research Satellite must accommodate thousands of pounds of instrumentation, GE Astro Space's mission is to keep the weight low, the tolerances tight and maintain all critical alignments.

To accomplish these tasks our engineers utilize the latest technologies to design lightweight structures and components. Through precision machining and exacting assembly procedures, skilled craftsmen realize these designs. As each spacecraft part is delivered to integration and test, practiced technicians perform and thoroughly demonstrate its interfaces to the spacecraft.

The cooperative spirit of our engineering, manufacturing and integration and test teams has given us the means to meet our mission while ensuring that our customer's science objectives are met without exception.

GE Astro Space

Demonstrated Excellence in Space

CONTENTS

July/August 1989
Volume 2, Number 4



Long after the sound and fury is forgotten, the Apollo Moon landings will remain the stuff of legend—and it all happened in our lifetime. See the photo-essay beginning on page 25.

Features

WINDOWS ON THE WORLD **18** *Earthgazing from Freedom's front porch*
By Alcestis R. Oberg

THE FUTURE AS IT WAS **20** *The space age before the Space Age*
By Les Dorr, Jr.

SPECIAL SECTION

ON THE MOON **25** *An Apollo photo album*
By Andrew Chaikin

WHERE HAVE ALL THE MOON ROCKS GONE? **50** *They're under lock and key, all 615 pounds of them*
By Beth Dickey

LUNA 2009 **52** *A look ahead to Apollo plus forty*
By Miles Weiss and Greg Freiherr

NEPTUNE AT LAST! **54** *Voyager's last stop on the "Grand Tour"*
By Tony Reichhardt

Departments

2 FROM THE PUBLISHER

4 THE OBSERVATORY

6 NOTES FROM EARTH
The art of Discovery, Japan's space scoop and more

10 LETTERS

12 GLOBAL CURRENTS
By Eric Lee
Israel's orbital debut

14 SHUTTLE MISSION FILE
Bon voyage, Magellan

16 BOUNDARIES
By Henry Fuhrmann
Whispers of the Big Bang

49 REVIEWS
Men From Earth

56 BACKYARD UNIVERSE
By Patricia Barnes-Svarney
Moonwalking by telescope

72 DESTINATIONS

FINAL FRONTIER (ISSN 0899-4161) is published bimonthly by Final Frontier Publishing Company, 2400 Foshay Tower, Minneapolis, MN 55402. Copyright © 1989 by Final Frontier Publishing Company. All rights reserved. Second class postage paid at Minneapolis, MN and additional mailing office. Subscriptions in the U.S.A., its territories and possessions, $14.95 for the year (6 issues). Canada, add $5 for postage. Other countries, add $9 for postage. POSTMASTER: Send address changes to FINAL FRONTIER, P.O. Box 3803, Escondido, CA 92025. Printed in the U.S.A. Mailed at Minneapolis, Minnesota and additional entry points. Certain editions may contain pages 16A & B and 48A & B. All art and photos courtesy of NASA, unless otherwise credited.

FROM THE PUBLISHER

You glorify the past when
the future dries up. —U2

That's the danger, of course. You get so caught up in reliving the old days that you stop looking ahead.

I was talking to some NASA executives recently. I'd been boasting that one of FINAL FRONTIER's objectives is to restore public interest in the space program to the level it was in the legendary 1960s, back when NASA was the envy of the world and astronauts were American heroes. Their response—that the space agency would prefer not to rest on its laurels—took me by surprise. Besides, they said, we were walking on the *Moon* in those days, for God's sake.

I understood what they meant. As far as stirring up the public imagination goes, how do you top men on the Moon? These are different times. Today, media coverage of the space program means space station budget wars and crew wake-up calls by Robin Williams. It's hard to imagine an episode of *Knot's Landing* being interrupted by a shuttle launch.

But even though I've been accused of being an eternal optimist, I still believe the best is yet to come. I think we can top men on the Moon.

As I write this, Voyager 2 is speeding toward Neptune, and the Magellan spacecraft is headed toward Venus. Both will open whole new worlds to the human imagination, and it's mind-boggling how *that* can be perceived as commonplace. If you ask me, those missions are miracles.

Looking ahead, there are plenty of worlds left to explore, including the 99.9 percent of the Moon's surface that the Apollo astronauts *didn't* visit. There are permanent space stations, Mars missions and the search for extraterrestrial life—all exciting, and all inevitable.

In this issue, we celebrate the past by marking the 20th anniversary of Apollo 11. Armstrong, Aldrin and Collins are modern-day heroes, and they and their fellow lunar explorers deserve our tribute.

But don't get us wrong. We don't intend to sit in our rocking chairs talking about how "Joe Louis was the greatest boxer that ever lived." Our real interest, and our responsibility, is to make sure the future *doesn't* dry up.

Ever upward,

William Rooney

William Rooney
Publisher

FINAL FRONTIER
THE MAGAZINE OF SPACE EXPLORATION

EDITOR
Tony Reichhardt

ASSOCIATE EDITOR
Les Dorr, Jr.

CONTRIBUTING EDITORS
Robert M. Powers
Beth Dickey

CONTRIBUTING PHOTOGRAPHERS
Tom Usciak
Mark Usciak

ART DIRECTOR
Alicia Nammacher

ART ASSISTANT
Julie Eggen

ART PRODUCTION
Tom Fisher

TYPESETTING
TypeMasters, Inc.

ASSOCIATE PUBLISHER
Carey Bohn
(612)332-2748

ADVERTISING AND PRODUCT SALES
Stephen Martin
(612) 332-3208

WESTERN REGIONAL MANAGER
Robert Halverson
(612) 227-0293

EASTERN REGIONAL MANAGER
Brian Rogers
(212) 371-0100

CIRCULATION DIRECTOR
Rebecca Sterner

PRESIDENT AND PUBLISHER
William Rooney

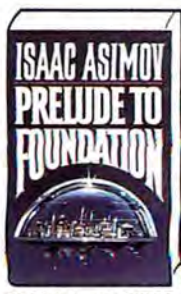
PUBLISHER'S ASSISTANT
Kirby Jones

SUBSCRIPTION SERVICE: Mail all subscription orders, changes of address (include latest label or give both old and new address) and other subscription correspondence to: FINAL FRONTIER, P.O. Box 3803, Escondido, CA 92025. (619) 485-7754

PUBLISHING, AND PRODUCTION OFFICE: FINAL FRONTIER, 2400 Foshay Tower, Minneapolis, MN 55402 (612) 332-3001. President: William Rooney. Founder: Robert Welch. Chairman and Chief Financial Officer: Robert Carroll. Advisory Board: Paul Tallis, V. Lindy Spassenko, Romney Tripp, Greg Mananian, Burten Carraher, Timothy John, Charles Allen.

EDITORIAL CORRESPONDENCE: Send submissions c/o the Editor, FINAL FRONTIER, P.O. Box 11519, Washington, D.C. 20008. We cannot be responsible for unsolicited material or photos. Article submissions must be accompanied by a self-addressed, stamped envelope. Opinions expressed in articles are those of the authors, and not necessarily of FINAL FRONTIER magazine.

THEORETICAL REALITIES REVEALED!



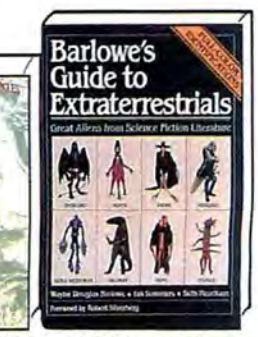
5314 Pub. ed. $18.95
Club ed. $6.98



4911 Pub. ed. $18.95
Club ed. $5.98



5462 Pub. ed. $18.95
Club ed. $5.98



3814 Spec. ed. ▲
Club ed. $10.98



1362 Pub. ed. $14.95
Club ed. $5.98



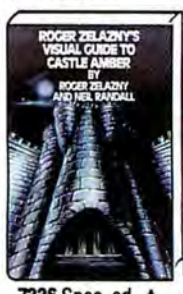
3962 Pub. ed. $19.95
Club ed. $9.98



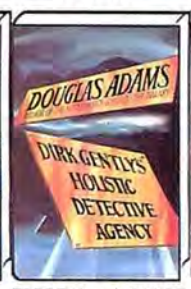
5413 Spec. ed. ▲
Club ed. $7.98



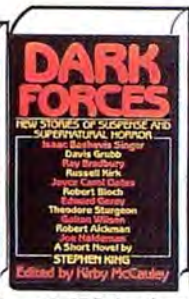
5728 Pub. ed. $17.95
Club ed. $7.98



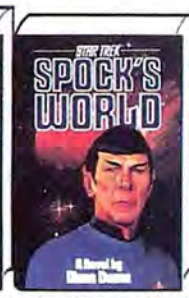
7336 Spec. ed. ▲
Club ed. $8.98



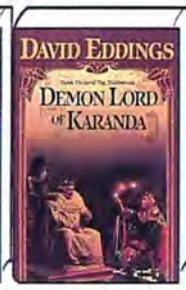
7369 Pub. ed. $14.95
Club ed. $4.98



★**9597** Pub. ed. $16.95
Club ed. $5.98



†**2816** Pub. ed. $16.95
Club ed. $6.98



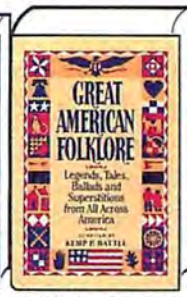
2998 Pub. ed. $18.95
Club ed. $6.98



5736 Pub. ed. $16.95
Club ed. $4.98



2311 Pub. ed. $17.95
Club ed. $5.98



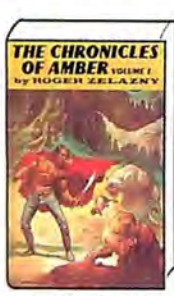
2667 Pub. ed. $16.95
Club ed. $6.50



★**4945** Spec. ed. ▲
Club ed. $8.98



★**4952** Spec. ed. ▲
Club ed. $8.98



0075 The First 5 Novels. 2 vols.
Comb. pub. ed. $32.30
Club ed. $9.98



1420 Includes the First, Second and Third Books.
Spec. ed. ▲
Club ed. $7.98



7260 Woundhealer's Story; Sightblinder's Story; Stonecutter's Story.
Comb. pub. ed. $45.85
Club ed. $7.98



7377 Seventh Son; Red Prophet; Prentice Alvin.
Comb. pub. ed. $53.85
Club ed. $9.98



7344 A Difficulty with Dwarves; An Excess of Enchantment; A Disagreement with Death. 3-in-1 vol.
Spec. ed. ▲
Club ed. $7.50



★**0745 Psion; Catspaw. 2-in-1 vol.**
Comb. pub. ed. $30.90
Club ed. $7.98



4937 The Reindeer People; Wolf's Brother. 2-in-1 vol.
Spec. ed. ▲
Club ed. $8.98



5876 Includes Swords and Deviltry; Swords against Death; Swords in the Mist. 3-in-1 vol.
Spec. ed. ▲
Club ed. $7.98



★**4929** Pub. ed. $17.95
Club ed. $4.98



7385 Spec. ed. ▲
Club ed. $4.98



FREE GIFT
with membership...
50 exciting, full-color Bookplates featuring SF art by Boris Vallejo.

TAKE ANY 5 BOOKS FOR $1 PLUS 50 FREE BOOKPLATES *with membership.*

How The Science Fiction Book Club works:

You'll receive your choice of any 5 books for only $1 (plus shipping and handling) and 50 FREE Bookplates after your application for membership is accepted. We reserve the right to reject any application. However, once accepted as a member, you may examine the books in your home and, if not completely satisfied, return them within 10 days at Club expense. Your membership will be canceled and you'll owe nothing. You may keep the 50 bookplates as a free gift.

About every 4 weeks (14 times a year), you'll receive the Club's bulletin, *Things to Come,* describing 2 coming Selections and a variety of Alternate choices. A few times a year, you may receive additional offers of special Selections, always at low Club prices. If you want the 2 Selections, you do nothing; they'll be shipped automatically.

If you don't want a Selection, prefer an Alternate or no book at all, just fill out the convenient form always provided and return it to us by the date specified.

We allow you at least 10 days for making your decision. If you do not receive the form in time to respond within 10 days and receive an unwanted Selection, you may return it at our expense.

As a member you need buy only 4 books at regular low Club prices during the coming year. You may resign anytime thereafter or continue to enjoy Club benefits for as long as you wish. One of the 2 Selections each month is always only $4.98. Other Selections are higher, but always much less than hardcover publishers' editions — UP TO 65% OFF. The Club offers more than 500 books to choose from. Each volume printed on our special presses is produced on high-quality acid-free paper. A shipping and handling charge is added to all shipments. Send no money now, but do mail the coupon today!

† Copyright © 1988 Paramount Pictures Corporation All Rights Reserved.
STAR TREK Is A Registered Trademark Of Paramount Pictures Corporation.

▲Exclusive hardcover edition
★Explicit scenes and/or language may be offensive to some

THE Science Fiction BOOK CLUB® Garden City, NY 11535

☐**YES,** I want to live the ultimate adventure in SF and fantasy. Please accept my application for membership in The Science Fiction Book Club. Send me the 5 books indicated in the boxes below plus my FREE Bookplates, and bill me just $1 (plus shipping and handling). I agree to the Club Plan as described in this ad. I will take four more books at regular low Club prices in the coming year and may resign at any time thereafter. The FREE Bookplates are mine to keep even if I decide not to remain a member. The Club offers serious works for mature readers. ES232

☐Mr.
☐Ms._____

Address_____Apt. #_____

City_____State_____Zip_____

If under 18, parent must sign_____

The Science Fiction Book Club offers its own complete hardbound editions sometimes altered in size to fit special presses and save you even more. Members accepted in U.S.A. and Canada only. Canadian members will be serviced from Canada. Offer slightly different in Canada.

04-SF49

THE OBSERVATORY

The Next Giant Leap

In order to survive, we need an ambitious goal.

▼ ▼ ▼

By Eugene Cernan

When we look back at what we've accomplished in space over the past two decades, it often seems as if Apollo came ahead of its time. The race to the Moon was born of political and technical competition—the Soviets also were spurred by the challenge of sending men to the Moon, and there's no question they were headed there until the United States reached the goal first. After that, the Soviets backed off to take a more systematic, assembly-line approach to putting things in orbit, which has served them well. But going out a quarter of a million miles and leaving the confines of our planet was a major technological and philosophical step well beyond simply orbiting the Earth, whether in a Gemini spacecraft or in the proposed Freedom space station.

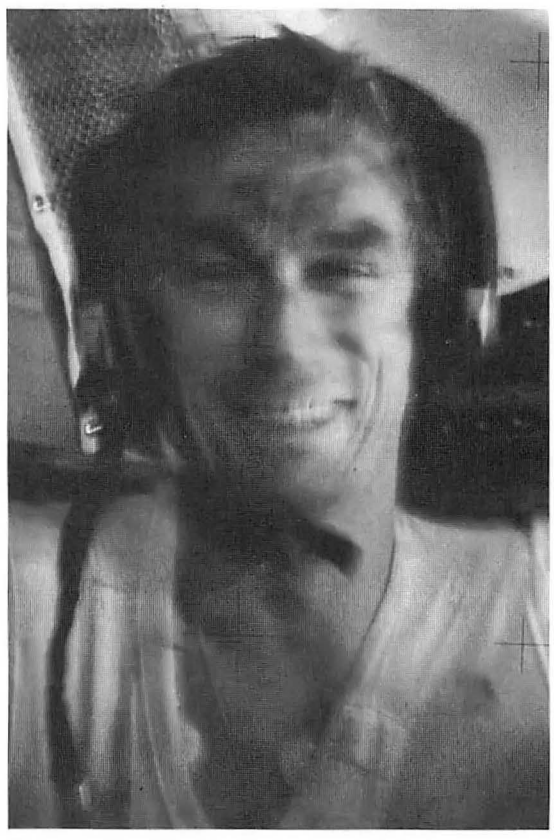
Is it still possible for an American president to take as bold a step as John F. Kennedy did in 1961, when he set his sights on the Moon? I believe so. But rather than focusing on a goal that's achievable in the next decade, we need a national goal that reaches out a generation into the future.

Today there is even more at stake than there was in 1961. The technological foundation that Americans have built and prospered from during the last hundred years is being eroded. Unless we find a vehicle for carrying forward the research and development upon which our economic affluence and world leadership depend, the foundation will crumble and crack.

What we need is a technological goal that the entire country, from young children to private industry, can look forward to over the course of the next 25 years—a continuing national goal that transcends political boundaries, that isn't changed or canceled every four years.

I happen to think the one goal that is both attainable and ambitious enough is Mars. It doesn't matter if this national goal is reached in 2008, 2015 or 2022. Let's just declare that sometime, a generation in the future, this country will place a human presence on Mars. Then, working backwards from that goal, we may decide that in order to achieve it we'll need unmanned scientific missions, expeditions to the Martian moons, more space shuttles, orbiting space stations or a base on the Moon. Along the way, new opportunities and benefits will come from those individual projects. Put all the steps together, and they make up a space program.

We have not had a space program in this country since the end of Apollo. In the 1960s, our endeavors in space were built around projects called Mercury, Gemini and Apollo, and those projects represented a national space *program*. Notwithstanding the fact that the shuttle is probably the most sophisticated flying machine Man has ever conceived, it is not a space program in itself. Each flight is a single event in a series of events. They are not steps to anywhere.



Cernan inside the lunar module Challenger during his stay on the Moon in December 1972.

Even NASA's proposed "next *logical* step"—space station Freedom—is not a visionary goal, but more a means to an end. From the space station will come great economic benefits, but unless we can predict what they will be—and that's impossible to do today—it is difficult to justify the space station politically.

After we've been to Mars, what's to keep the country from abandoning its space program the way *it* was abandoned after Apollo? For one thing, we are more mature in 1989 than we were in 1961. We had tunnel vision during the Apollo days—we were headed for the Moon, and there was a date we had to be there. But the technological infrastructure that evolves from a 25 year-long space *program* will permanently embed itself in our society. And from such a long-term effort, we finally will see the development of commercial operations in space, which will help carry the economic burden.

This next great leap does not have to be a solo. In 1961, the United States and the Soviet Union were the only countries capable of even thinking about going to the Moon. We *owned* space. But that isn't so anymore, and the first landing on Mars might well be an international effort involving many countries.

Still, there are great risks to our economic security if the United States does not have an ambitious space program of its own. If we back off and say, "We've done it all, we've gone to the Moon and invented a space shuttle," and we let others build on our technological competence, we'll be in an unacceptable position. Politically and economically, we can't afford *not* to be in a position to influence the course of the next giant leap in space, and, ultimately, to determine our own destiny.

Eugene Cernan was the commander of the Apollo 17 mission and the last person to leave the Moon's surface. He now lives and works in Houston.

AMERICA'S DREAM

Signature Collection of Apollo and Gemini Astronauts



AMERICA'S CHALLENGE
Eugene Cernan, APOLLO XVII



ROAD TO DISCOVERY
Alan Shepard, Jr., APOLLO XIV



EARTHRISE
Thomas Stafford, APOLLO X



SPECTRUM OF GLORY
Alan Bean, APOLLO XII

- Limited Edition of 500
- Each hand signed
- Certificate of Authenticity
- Personal written narrative by astronaut
- Historic first ever offering



SIGHTSEEING
James Lovell, Jr., GEMINI XII

Journey to space with the astronauts of the Apollo and Gemini missions. Share in the dream which these great American voyagers carved into American history books. This is an extraordinary opportunity to own a remarkable collectors edition of limited edition prints personally selected by the astronauts as representative of their missions.

SPECIAL AND PERSONAL

These exceptionally unique photographs have been individually selected by the astronaut who took the spectacular photograph pictured. These photographs are each unretouched originals. Each originally reproduced photograph is personally signed by the astronaut. A handsome 11 x 17 Certificate of Authenticity and a fascinating personal story written by the astronaut appearing on the Certificate accompanies each limited edition print. Each print is serially numbered between 1 and 500 and the owners name and serial number will be inscribed on the Certificate.

LIMITED EDITION OF 500

This is the first and only time these men of Apollo and Gemini have signed an originally reproduced photograph, which they have taken on their mission, as an art piece in a collectors limited edition series. These magnificently detailed photographs (original negatives obtained from NASA archives) are professionally and individually reproduced on Kodak Ektaprint paper with an image size of 14 x 15½ inches on a 16 x 20 inch format. There exists *only 500* of each hand signed print so availability is extremely limited nationally. Each piece has a 1 inch border on top and sides with a 3½ inch border at the bottom to allow for titling, signatures and numbered serializing. Subsequent to signatures the limited edition prints are individually laminated with a 5 mil optical laminate to protect the signatures and photographic emulsions.

A HISTORIC FIRST

Whether you have an interest in space exploration...enjoy the idea of owning a rare and first of its kind offering...seek to acquire an outstanding series of famous astronauts signatures on personally selected photographs...or simply take great pride in our nations history, this is a collection you and generations to come will treasure.

ORDER NOW!

These very rare and unusually limited handsigned photographs taken by the astronaut, with a personalized story included are now available on a *first come first serve* basis. Your investment price is $160.00 per print. *As a special savings you may order a complete set of each print at the special price of $600.00.

RESERVATION

Send Check or Money Order to:
Pacific Coast Galaxy Publishers
P.O. Box 7338, San Diego, CA 92107

My check or money order is enclosed for:

- ☐ America's Challenge-Eugene Cernan
- ☐ Road To Discovery-Alan Shepard
- ☐ Earthrise-Thomas Stafford
- ☐ Spectrum Of Glory-Alan Bean
- ☐ Sightseeing-James Lovell
- ☐ All Five

Due to the limited nature of the prints and in the event your first choice is sold out, we are offering you the opportunity to make a 2nd, 3rd, 4th or 5th choice. Please mark by number your preference in the boxes provided designating 1,2,3,4 or 5.

- Shipping and insurance included.
- California residents add 6.5% sales tax.
- Questions re: ordering call **(619) 224-9629.**

Please include

Name _____

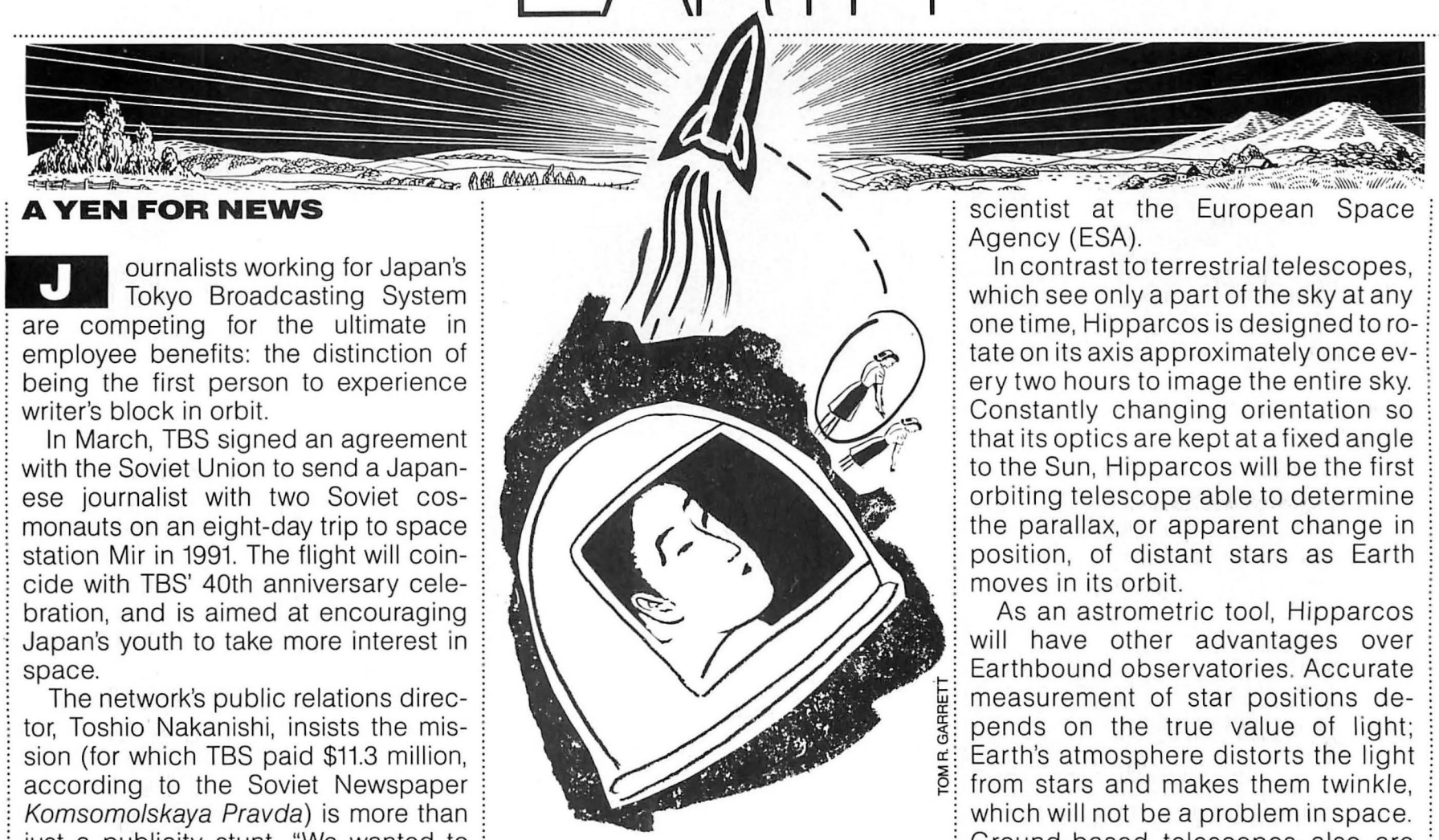
Address _____

City _____

State _____ Zip _____

Allow 3 to 4 weeks for delivery.

NOTES FROM EARTH



A YEN FOR NEWS

Journalists working for Japan's Tokyo Broadcasting System are competing for the ultimate in employee benefits: the distinction of being the first person to experience writer's block in orbit.

In March, TBS signed an agreement with the Soviet Union to send a Japanese journalist with two Soviet cosmonauts on an eight-day trip to space station Mir in 1991. The flight will coincide with TBS' 40th anniversary celebration, and is aimed at encouraging Japan's youth to take more interest in space.

The network's public relations director, Toshio Nakanishi, insists the mission (for which TBS paid $11.3 million, according to the Soviet Newspaper *Komsomolskaya Pravda*) is more than just a publicity stunt. "We wanted to show that the common man, after training, can go into space," he explains.

Health and age—applicants must be under 45—are the most important criteria for selection. To ensure that the project gets off the ground, TBS will choose two finalists of the same sex for the flight. The prospective spacefarers will receive about 18 months of training, including a crash course in Russian, and each will practice with a different pair of cosmonauts. The Soviets will decide which crew will make the trip on the day before the launch, tentatively scheduled for July 1991.

During the voyage, the TBS cosmonaut will make daily TV and radio broadcasts, take photographs and record his or her impressions of the flight. Once the reporter's feet are back on the ground, a lecture tour awaits. "We want the journalist to share the experience," says Nakanishi, adding that the employee-astronaut will be encouraged to write a book about the trip.

By mid-April, TBS had already received ninety applications for the assignment; eight were from female TBS journalists, and four were considered long shots because the applicants aren't employed by the network. Nakanishi wasn't saying exactly when the finalists might be chosen, but hinted that it could be as early as this summer. —*Mary O'Neill*

TOM R. GARRETT

STAR TRACKS

Two thousand years after the Greek astronomer Hipparchus compiled the earliest star catalogue, the European Space Agency plans to orbit the first satellite dedicated to astrometry—the exact determination of the position of celestial objects.

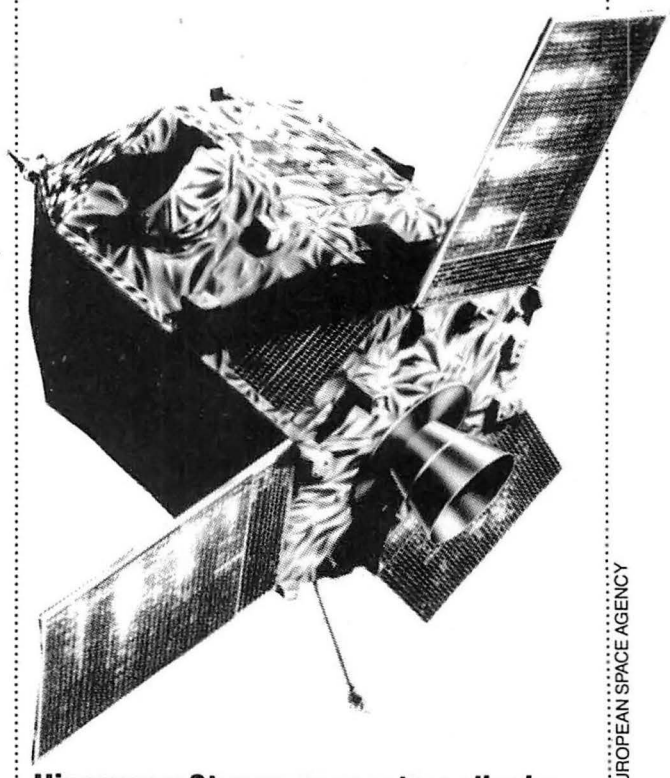
The High Precision Parallax Collecting Satellite—Hipparcos for short—will be launched this summer to measure precisely the positions, motions and parallaxes of more than 100,000 stars. Researchers hope the two-and-a-half-year mission will answer many questions about the most basic processes in the universe.

"Hipparcos will provide an enormously valuable data base for continuing studies of stellar structure and evolution, galactic motion, celestial mechanics and a wide variety of other astronomical applications," says Michael Perryman, Hipparcos project scientist at the European Space Agency (ESA).

In contrast to terrestrial telescopes, which see only a part of the sky at any one time, Hipparcos is designed to rotate on its axis approximately once every two hours to image the entire sky. Constantly changing orientation so that its optics are kept at a fixed angle to the Sun, Hipparcos will be the first orbiting telescope able to determine the parallax, or apparent change in position, of distant stars as Earth moves in its orbit.

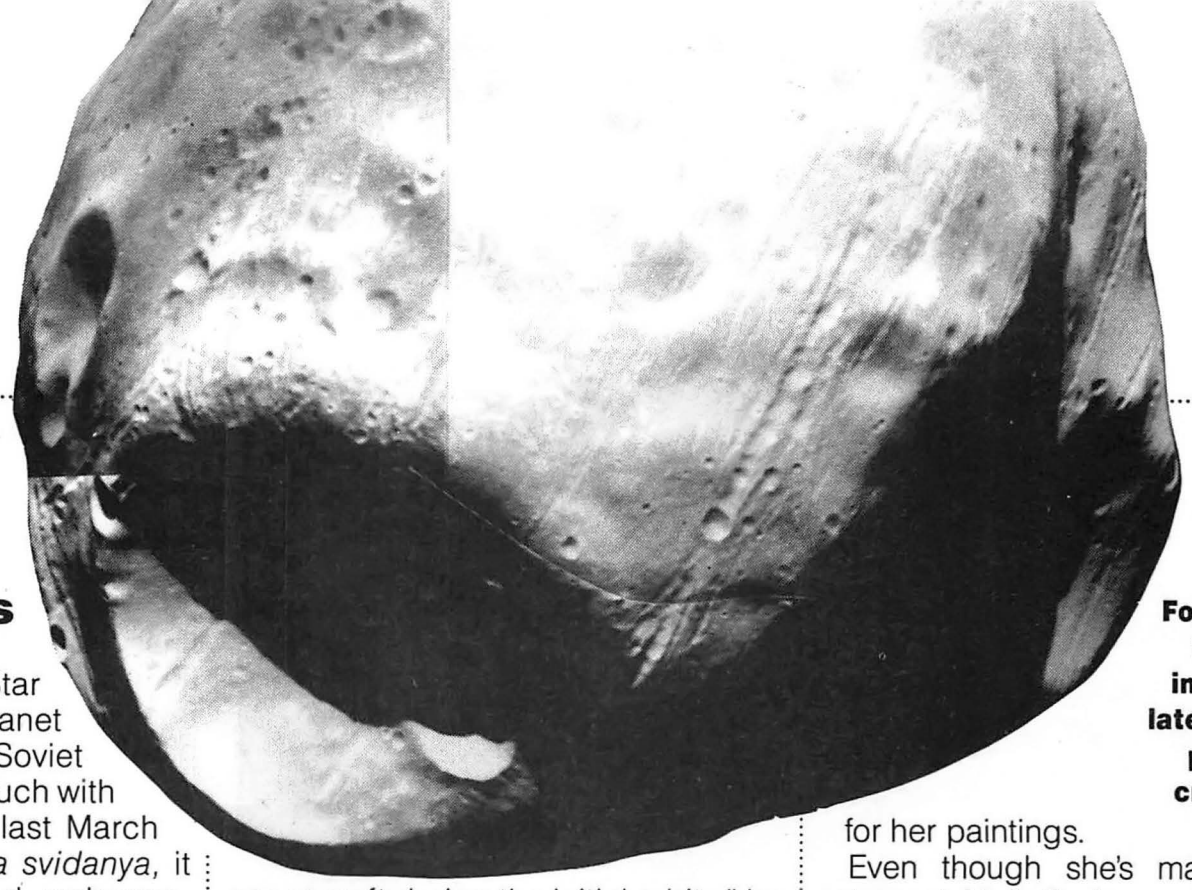
As an astrometric tool, Hipparcos will have other advantages over Earthbound observatories. Accurate measurement of star positions depends on the true value of light; Earth's atmosphere distorts the light from stars and makes them twinkle, which will not be a problem in space. Ground-based telescopes also are hampered by slight deformities brought about by gravitational and thermal instabilities.

With Hipparcos, "We can expect a major revision of the [estimated] distances in the universe," says the University of Geneva's Michel Grenon, adding that "We can also expect the unexpected." —*C.S. Lambert*



EUROPEAN SPACE AGENCY

Hipparcos: Star-mapper *extraordinaire*.



Fobos never got the chance to improve on this late-1970s Viking photo of Mars' cratered moon.

"FOBOS" PHLOPS

Maybe the Red Star and the Red Planet just don't mix. When Soviet ground controllers lost touch with the Fobos 2 spacecraft last March without so much as a *da svidanya,* it brought a premature and embarrassing end to the $480 million, high-profile planetary mission, and raised questions about the Soviets' ability to pull off an ambitious program of Mars exploration slated for the 1990s.

Soviet project managers had pinned all their hopes on Fobos 2 after its companion probe, Fobos 1, was lost due to a human computer programming error six months earlier. The second probe reached Mars orbit in late January, returned detailed images of the planet, and began maneuvering toward what was to have been the mission's highlight—a close encounter with the tiny moon Phobos. As planned, Fobos 2 broke its communications lock with mission control in Kaliningrad on March 27 to obtain images of Phobos that would assist trajectory planners. The spacecraft was programmed to turn its high-gain antenna back toward Earth at the end of the photo session. But after a brief, weak signal, Fobos 2 was silent, and subsequent attempts to reacquire its signals failed.

The Mars mission wasn't a total loss, however. Radio Moscow reported that Fobos 2 had returned pictures showing several unexplained terrain features on Mars, including an "enigmatic strip" about 15 miles wide. The spacecraft also sent back a wealth of scientific data about the Martian environment: "In certain areas, such as particles and fields [experiments], the majority of what was expected was returned," says University of Michigan Professor Andrew F. Nagy, whose team designed one of Fobos' instruments in conjunction with Hungarian physicists.

Larry Esposito of the University of Colorado was equally happy with the probe's infrared studies of the Martian atmosphere. "A lot of new data with significant value was gathered by the spacecraft during the initial orbits," he said.

And despite the loss of both Fobos probes, at least some of the Soviet Union's potential space partners in the West weren't willing to write off future collaborative efforts. "It's much too early to say if [the failure] will make people more wary," says Peter Smith, NASA's deputy director of international relations. "They know that space science is hard. Things go wrong."

Nagy is even more optimistic. "There are going to be other opportunities," he predicts, "and people will still be anxious to get involved."—*Les Dorr, Jr.*

SHUTTLESCAPES

The world may have been watching when space shuttle Discovery thundered off the launch pad last March, but few people saw the work that went into getting the STS-29 mission ready to fly.

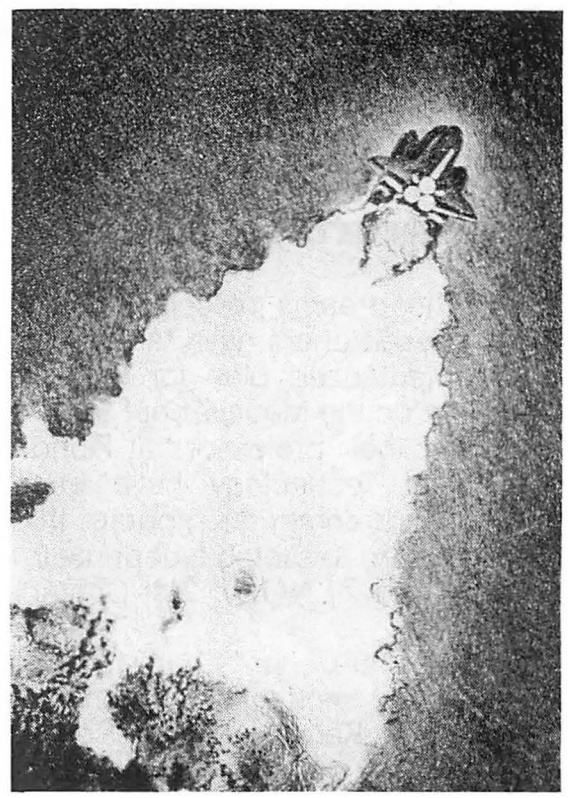
Artist Molly Springer, the wife of astronaut Robert C. Springer, was one of the lucky few who did. Now she's creating a series of watercolors based on her behind-the-scenes view of preparations for the flight on which her husband and his crewmates deployed a $100 million Tracking and Data Relay Satellite.

Mrs. Springer, a member of the NASA art team, also was one of several artists commissioned to document the flight of Atlantis in April. Her painting will become part of NASA's official art collection.

But her STS-29 mission series offers a glimpse at the inner workings of the shuttle program. For months, she followed Springer and his fellow astronauts through their pre-flight training, filling several thick albums with photographs to be used as references for her paintings.

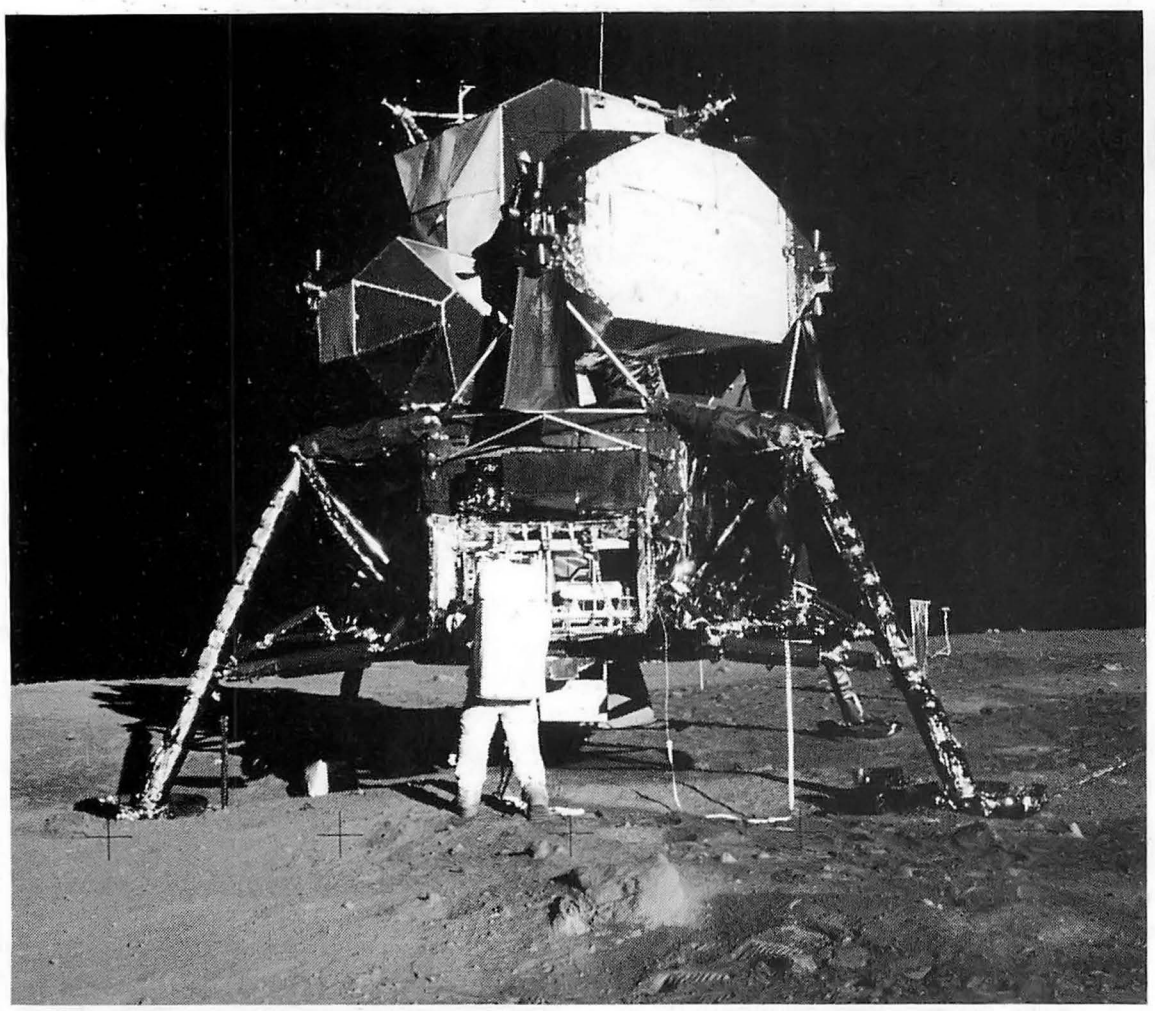
Even though she's married to an astronaut, Molly Springer says she didn't get any special treatment. When she couldn't tag along, she left the photography chores to her husband, who describes himself as "one of those guys who likes to carry a camera with him every place he goes."

One day on a practice jaunt in a T-38 jet trainer, he snapped a couple of shots of himself flying the aircraft. "It was one of those silly things you do, but it came out rather well," Springer boasts.



"Ascent From the Maelstrom," by Molly Springer.

Most of the time, though, Mrs. Springer pointed her lenses at workers who "never get on camera, never get in paintings, the people who make it all possible." Spaceflight is "a tapestry of people who really care what happens," she says. "It just so happens that the astronaut is the one we generally see the most." —*Beth Dickey*



NASA's next Moonport will improve on the "primitive" launch pad used for Apollo.

MOONPORT ALPHA

The dreams of some Florida researchers have taken wing in a computerized plan for the first spaceport on the Moon. About 30 students and their professors at Florida Institute of Technology have been working on a computer program that might be used to sketch blueprints for the lunar hub of NASA's 21st Century spaceline.

"Complex 39-L" (for "lunar") is modeled after the shuttle launch complex at the nearby Kennedy Space Center. The university group envisions Complex 39-L as a port for spaceships that would shuttle crews and cargo between a supply station in lunar orbit and a 30-person base on the Moon.

The F.I.T. researchers, working for NASA on a $90,000 grant from the Universities Space Research Association, stopped short of building a scale model. Instead, they used a computer to try out site plans and construction methods for the Moonport.

Their prototype includes a "Vehicle Assembly Tent," a quonset hut where vehicles resembling the Apollo-era landers could be put together, checked out and loaded with cargo; a paved pad for as many as 24 launches and landings per year; storage tents for fuel, cargo and worn-out landers; and an underground range control and communications center.

The job of modeling the Moonport has been left to private companies chosen to submit design studies to NASA. The space agency borrowed heavily from F.I.T.'s research in requesting those studies, according to Jerald Linsley, an associate professor of chemical engineering who leads the project. "We feel that's a mark of our success," he boasts.

So far there are no cost estimates attached to the Moonport concept, which assumes the existence of costly, yet-to-be-realized technology. Furthermore, the group takes for granted that taxpaying Americans will agree that a Moon base is worth the money.

"We don't know enough about what's going to happen when we get to the Moon to say *now* whether it will be worth it or not," Linsley says to questioning skeptics. "It boils down to the Sir Edmund Hillary answer on Everest: 'Because it's there.' It's in our nature."

—Beth Dickey

GETTING THERE IS HALF THE FUN

Most people know the Galileo project as NASA's long-awaited return to the giant planet Jupiter. But when the planetary probe finally is launched from the space shuttle this fall, it will still be six long years from its goal, and NASA scientists don't plan to let Galileo slumber on the way to its final destination.

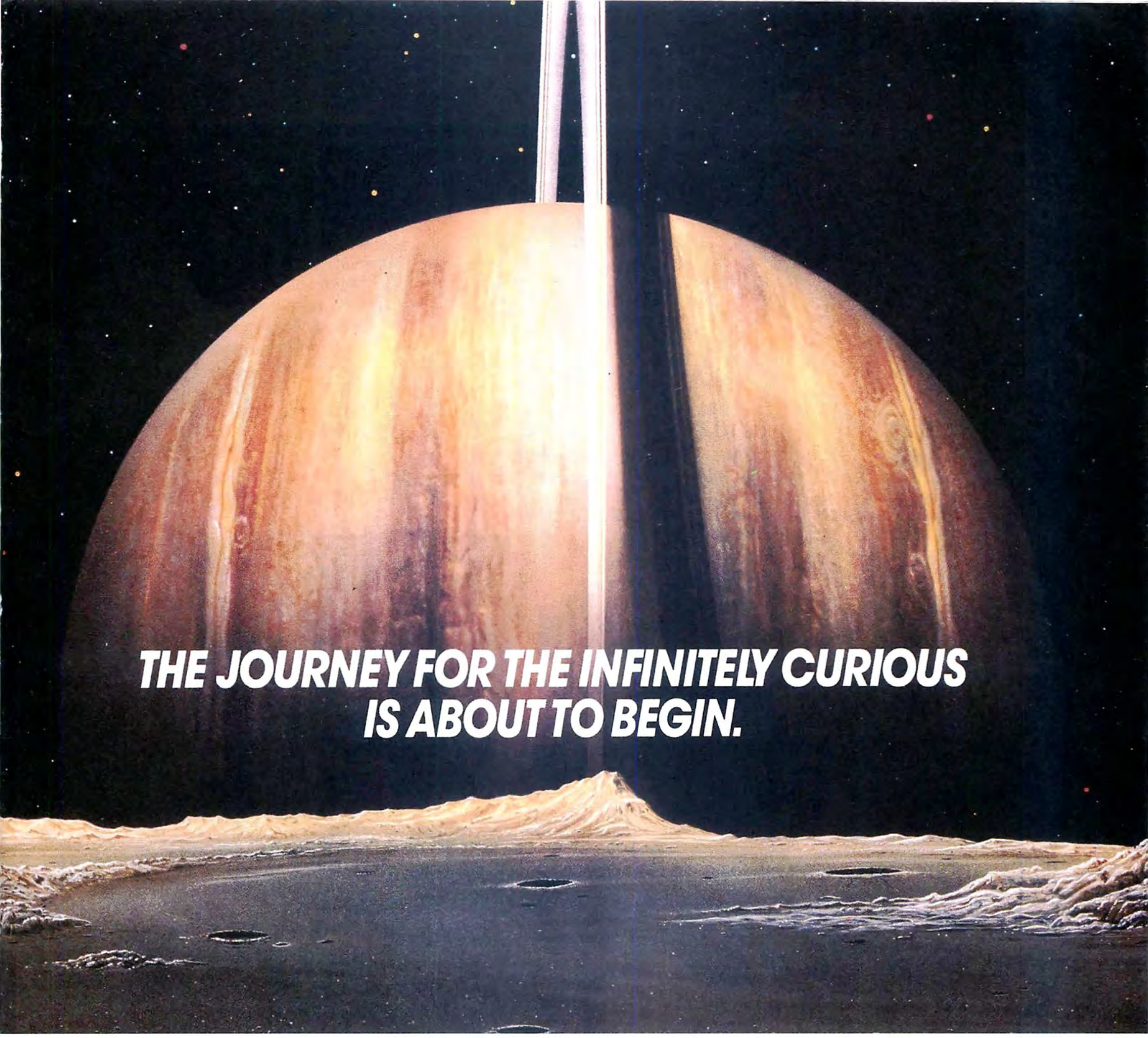
Following a circuitous route known as a Venus-Earth-Earth-gravity-assist (VEEGA), which is necessary to gain enough energy to reach the outer Solar System, the spacecraft will swing by the Earth-Moon system twice: in December 1990 and again in December 1992. For the past year, Theodore Clark at the Jet Propulsion Laboratory and the University of Hawaii's Fraser Fanale have been working with lunar and remote sensing specialists to take advantage of this golden opportunity to turn Galileo's instruments on our own neighborhood before they encounter "the big one." According to Fanale, Galileo may give us new, unparalleled glimpses of the Moon's hidden side. Teaming a solid-state charge-coupled device camera with a mapping spectrometer in the near-infrared part of the spectrum, scientists hope to get their first data about the distribution of minerals like olivine and pyroxene in the farside lunar soil.

The two Earth passes also will present opportunities for mapping water and carbon dioxide, plus methane and other "greenhouse" gases, in our own planet's atmosphere. As a bonus, Galileo may gather images that can be

After leaving Earth orbit, Galileo still has several "stops" to make before reaching Jupiter.



JPL



IT STARTS WHEN YOU TURN THE PAGE.

Pictured above: an artist's image of Saturn rising above one of its moons. Each of this planet's 17 satellites is so individual and idiosyncratic as to be a world unto itself.

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 659 RICHMOND, VIRGINIA

POSTAGE WILL BE PAID BY ADDRESSEE

TIME LIFE®

1450 E. PARHAM ROAD
RICHMOND, VA 23280-9983

INTRODUCING VOYAGE THROUGH THE UNIVERSE FROM TIME-LIFE.

NOW YOU CAN GO FURTHER THAN YOU'VE EVER BEEN.

Ever wonder what it would be like to visit a neutron star? Disappear down a black hole? Witness a supernova explosion? See a cosmic string vibrate or watch two spiral galaxies collide? Or enjoy another kind of thrill—the pleasure of really understanding how these marvels work and what they mean?

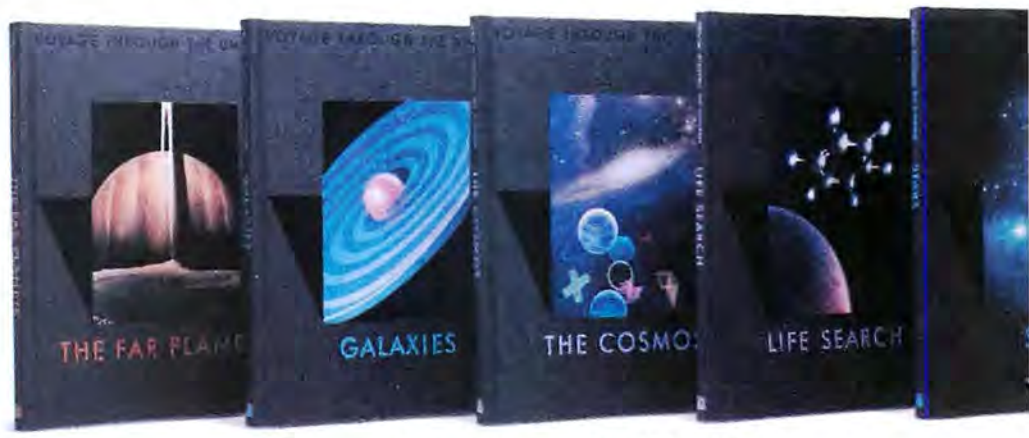


See for yourself what happens when a massive black hole devours a hapless object—and mangles the very fabric of space and time. In **Stars.**

Now it's all possible for you. In a brand new library from TIME-LIFE *that's big enough, bold enough and beautiful enough to capture the splendor of the cosmos in its pages. VOYAGE THROUGH THE UNIVERSE is unlike any other work on the subject you've ever seen. Other books just* tell *you about the awesome events unfolding in space. But* we show you. *We make you feel like you're really there—with a whole new genre of gorgeous art and vivid pictorial essays that makes even the most difficult concepts crystal clear.*

Comprehensive, authoritative, up-to-date, VOYAGE THROUGH THE UNIVERSE is as colorful and entertaining as the marvels it describes—yet doesn't oversimplify or omit important details. From "mini" black holes and the Big Bang to future lunar colonies and the search for extraterrestrial life, you'll discover amazing facts. Learn astonishing new theories. Even glimpse what scientists have on the drawing board for the 21st century and beyond.

Ready for the voyage to begin? Then send for your first volume, **Stars,** *where you'll explore mindboggling objects like black holes, pulsars, supernovae, red giants. Continue your adventures with* ***The Far Planets, Life Search, Galaxies, Outbound, The Cosmos*** *and other volumes in the library. Receive one about every other month and enjoy it FREE for 10 days. Keep it by paying just $14.99 plus shipping and handling.* (An unheard of price for a hardcover this magnificent!) Buy only the books you like. Cancel anytime. Even enjoy one of the best money-back guarantees ever (see reply card for details).*





Get a close-up look at our own Milky Way, then go even closer—and discover why there may be a black hole lurking at its center. In **Galaxies.**



This creature, called a tardigrade, can survive an entire century without a drop of water. If life like this can exist under extreme conditions on Earth, why not elsewhere in our solar system? Explore the possibilities in **Life Search**

*Does VOYAGE THROUGH THE UNIVERSE sound like the kind of journey that can excite your curiosity in a very special way? Then join us now—*at no risk *—by mailing the reply card at left.*

START YOUR JOURNEY WITH Stars FOR 10 DAYS FREE.

Yes, I'd like to take a free 10-day look at **Stars,** *as my introduction to VOYAGE THROUGH THE UNIVERSE. If I decide to keep it, please send me more volumes to examine under the terms described in this ad.*

With **TIME-LIFE'S Unconditional Guarantee of Satisfaction** *you can return any book you've bought, anytime in the future, for a full refund. No questions asked.*

Name _____

Address _____ Apt. _____

City _____ State/Province _____ Zip/Postal Code _____

EDASL5

Send no money. Just detach and mail this card today.

**In Canada, volumes are $18.99 each.*

Canadian residents mail card in envelope. All orders subject to approval. Price subject to change.

© 1989 Time-Life Books, Inc.

VOYAGE THROUGH THE UNIVERSE

NEW FROM TIME LIFE®

NOW THERE'S NO LIMIT TO HOW FAR YOU CAN GO.

made into movies of the crescent Moon as it glides past the crescent Earth.

Taking data during these quick fly-bys won't be easy. The spacecraft will hurtle past Earth "like a bat out of hell," says Fanale. The first fly-by will be at a distance of less than 500 miles, only three times as high as the space shuttle typically orbits, and the second will be even closer. In the process, we may well get the answers to a few nagging questions—such as whether there really is a rain of small comets continually pelting the Earth, as some scientists have proposed.

—Ray Spangenburg and Diane Moser

MISSION TO OZ

A trip to OZ is being planned by a husband and wife scientific team at the Jet Propulsion Laboratory in Pasadena, California. But instead of a yellow brick road, the trip will make use of a sophisticated spacecraft designed by Aden and Marjorie Meinel.

In this case, "OZ" stands for Oort Zone, an area just outside our Solar System where experts believe most comets originate. The Meinels have been working on the project since the summer of 1985 in response to a suggestion by JPL administrator Lew Allen. They dubbed the mission "TAU" for "thousand astronomical units," the distance the probe would travel. One astronomical unit is the distance from Earth to the Sun—about 93 million miles.

TAU would use nuclear propulsion to reach a speed of more than 225,000 mph, faster than any previous man-made object. It would take 50 years to reach the inner part of the Oort Cloud, sending back a wealth of scientific data during its long journey.

"There are a lot of questions about the outer Solar System we need to answer," Aden Meinel says. "For instance, are there a large number of objects in the Oort Zone and if so, where did they originate?"

Another of TAU's major objectives is to help astronomers precisely measure the distances to other stars—something they can't do from Earthbound observatories. The Meinels also believe the spacecraft may find undiscovered stars within a dozen or so light-years from our sun.

TAU won't be cheap; there's no firm price tag, but the flight likely will cost well over $1 billion. Still, the Meinels hope the project can be fully funded by 1999 and launched early in the next century.

"Both of us will be retired long before then," Aden Meinel says. "That's why we're looking for young astronomers to work on the project with us. We'll wave goodbye to it—but they'll reap the benefits."

—Ken Wells

COOL SOUNDS

For decades, NASA has been stuck on the problem of creating a refrigerator that would operate in zero-gravity. The cold, hard fact is that conventional refrigerators won't do in space because their moving parts are susceptible to breakdowns in weightlessness, preventing them from removing heat. Now a team of scientists at Los Alamos National Laboratory has developed a refrigerator that runs on sound, and NASA may have a prototype unit working on a shuttle mission within a year.

"Basically, a group of scientists got together to solve what appeared to be a goofy problem," says Greg Swift, a physicist who helped to develop the space refrigerator. The Los Alamos group solved the problem by using an ordinary hi-fi mid-range for power. The refrigerator sends sound wave oscillations through compressed helium in a high-pressure tube. The helium expands and contracts as much as 1,000 times a second, producing magnetic energy and heat. The magnetic energy is then converted into electricity for cooling, and the heat is expelled through heat exchangers in a process Swift describes as similar to breathing.

"We get roughly dry ice temperatures," he notes, adding that since the device has no moving parts, it should operate reliably in a gravity-free environment.

A research team at the Naval Postgraduate School in Monterey, California is conducting further experiments with the sound refrigerator. Swift predicts that if the unit proves itself on the shuttle, sound refrigerators could become household items within ten years, leaving the old, conventional gravity-dependent refrigerators out in the cold.

—Joseph Baneth Allen

GALACTIC EVENTS

JULY 16-24

The 20th anniversary of the first lunar landing will be celebrated in Spaceweek activities nationwide. Scheduled events include a short public ceremony on July 20 honoring the crew of Apollo 11 at the National Air and Space Museum in Washington; a 20th anniversary gala in Houston on July 21, sponsored by the American Institute of Aeronautics and Astronautics; and a parade in Clear Lake, Texas, home of NASA's Johnson Space Center, on July 22. For a calendar of all the many programs, exhibits and events planned around the country, or for information on how to sponsor a 20th anniversary event, write to Spaceweek National Headquarters, P.O. Box 58172, Houston TX 77258.

JULY 16

Carlisle, Pennsylvania. Space Collectors Convention. According to the Society for the Advancement of Space Activities, this is the first ever gathering of space collectors, who'll be buying, selling and trading memorabilia from the first three decades of space exploration. For information, write SASA, 1797 Cessna St., Carlisle PA 17013, or call (717) 243-9043.

AUGUST 23-27

Pasadena, California. Planetfest '89, a five-day multimedia extravaganza sponsored by The Planetary Society and timed for Voyager's fly-by of Neptune, offers public lectures, symposia, film festivals and exhibits. For information, write Planetfest, The Planetary Society, 65 North Catalina Ave., Pasadena CA 91106.

DAN PICASSO

ORBIT
A FOUNDATION SERIES

For The Space Enthusiast !!

INTRODUCTION TO SPACE:
The Science of Spaceflight
by Thomas D. Damon
Orig.Ed.1989(Orbit)
248 pp.
CL.$39.50 Ppb.$27.50
Cl. ISBN 0-89464-016-X
Ppb. ISBN 0-89464-028-3

Please send for our free catalog.

When ordering please add $4.00 for first book, $1.00 each additional (Ppb. $2.50, $1.00 each additional) to cover shipping charges.

ORBIT BOOK COMPANY, INC.
A division of
Krieger Publishing Co.
P. O. Box 9542
Melbourne,FL
32902-9542
(407)724-9542



★ LIMITED EDITION ★

1st Manned Lunar Landing 20th Anniversary Plate

Proudly display this artfully etched moonscape on fine glass. This beautiful commemorative will be created for only 60 production days, then the special edition will be permanently closed. To reserve your plate, order before September 30. Orders after that date will be subject to limited supply availability.

100% Satisfaction Guaranteed

Send check or money order to:
Etch-N-Things Dept. MA, P.O. Box 268,
Worthington, Ohio 43085

Also available at Neil Armstrong Air & Space Museum, Wapakoneta, OH

☑ I would like ____# Commemorative Plates. I have enclosed $32.50 for each (postage and handling will be paid by Etch-N-Things).

Name _____

Address _____

City _____ State _____ Zip _____

LETTERS



TOM R. GARRETT

Mars Can Wait

Your April issue placed undue emphasis on a near-term manned Mars mission. This hype raises unrealistic hopes for a highly dubious objective. Tony Reichhardt acknowledged that any Martian trip would cost billions and billions, and would risk the kind of fate the Apollo program suffered: skepticism and insufficient continuing resources to sustain our space program after the big splash (or bust) of the expedition. Our Apollo program should have been prefaced by space station development, so that we'd have more than a few Moon rocks for the effort—a course the Soviets chose to great effect (Mir) when they broke off the Moon race. We need more for our money than a romantic race to Mars by some adolescent test pilots for some red dust. Carl Sagan notwithstanding, Mars is probably the most boring object in the Solar System (the Moon would be, but for its proximity to Earth.)

Let's instead really develop near-Earth space—with solar power satellites, habitats, lunar mining and all the rest—to build a sturdy platform for the great adventures ahead. Mars will still be waiting, as it has been for four billion years. Otherwise, we risk squandering our wealth and ultimately abandoning leadership in space to others.

D. Allan Meyer
Phoenix, Arizona

Whose Frontier?

Regarding your magazine title, FINAL FRONTIER: whose final frontier is it? America's? In all fairness to those truly interested in the space sciences and technologies, more coverage of other countries' achievements in space are needed. The USSR, European Space Agency and Japan are commonly neglected in our media, even though their contributions in this area are significant.

It's a sad note we sing when all we hear about are "competitors" on a playing field. I personally don't find anything un-American about being interested in any form of science. Up to this time in our history, any undertaking in the realm of science that has been considered worthwhile has been a collaboration on the part of many dedicated individuals who come from different countries.

If we are truly to succeed in conquering the "final frontier," the whole must be considered greater than the individual parts. In other words, to cross the boundaries of deep space, the boundaries of countries will first need to be crossed. Your magazine can help bridge these terrestrial barriers.

Barry E. DiGregorio
Niagara Falls, N.Y.

Face-Off

Regarding your review of Richard Hoagland's book *The Monuments of Mars* (December 1988): Hoagland's writing style does damage to the cause of we who seek a fair appraisal of this interesting Martian feature and its adjacent "structures." Some of the points he brings out are interesting, for instance the fact that the original name given to Cairo meant "Mars." Hoagland's assertions are disavowed by Vincent DiPietro, the original researcher of the face. Your review leaves the impression that the face is not worth investigation. In light of what research DiPietro and Greg Molenaar have gathered, the conclusion you reach is really not fair.

Patrick B. Kelly
Monrovia, California

FINAL FRONTIER welcomes your letters. Send them c/o Letters to the Editor, FINAL FRONTIER, P.O. Box 11519, Washington, D.C. 20008. Please type your correspondence and limit the length to 150 words.

HISTORICAL BEGINNINGS

Signature Collection of American and Soviet Pioneers



Size: (25" x 35") 1" Border

Artist: George Bishop

MERCURY 7

MANY WERE CALLED, BUT SEVEN WERE CHOSEN

On May 5, 1961, America launched the historic beginnings of her space program. Our famous Mercury astronauts have come together since those historic beginnings to commemorate for the first and only time the Mercury program with this historically significant limited edition offering. The very visual and breathtaking "Mercury 7" offset lithograph was commissioned and each historic art print hand signed by "The Right Stuff" astronauts, Senator John Glenn, Alan Shepard, Walter "Wally" Schirra, Gordon "Gordo" Cooper, Donald "Deke" Slayton, Betty Grissom (for Gus), and Scott Carpenter.

- **Limited Editions of 1500**
- **Each Hand Signed**
- **Certificate Of Authenticity**
- **Historic First Ever Offering**

APOLLO-SOYUZ

IT BEGAN WITH A HANDSHAKE

On July 17, 1975, a most historic handshake took place that changed the course of history. It can truly be said that in 1975, high above the earth, the seeds of openness, of Glasnost, were planted and are blossoming today. We have recaptured for the first and only time this historic handshake with the issuance of this once only limited edition. The specially commissioned and dramatic "Apollo-Soyuz" offset lithographs are each hand signed by the two famous Soviet cosmonauts who flew the mission, Alexi Leonov (first man to walk in space) and Valeri Kubasov, and for the Americans, mission commander Thomas Stafford and Donald "Deke" Slayton.

LIMITED EDITION OF 1500

This is the first and only time these legendary men have together signed an art piece for limited edition collectors. *It will not be repeated.* Only 1500 have been published of each print shown and each is individually serial numbered between 1 and 1500. The serial number and owners name will be inscribed on the handsome 11 x 17 Certificate of Authenticity. Serial number 1 of each piece is being presented to President George H.W. Bush.

A SPECTACULAR SHOWPIECE

Anyone fortunate to own the signatures of our aviation pioneers such as the Wright Brothers and Charles Lindbergh know how valuable and collectable these signatures have become. Our Mercury 7 astronauts and the American astronauts and Soviet cosmonauts who signed these historic limited editions are no exception. Their signatures are rare and have already become highly sought after and quite valuable.

FIRST EVER

As the first commemoratives ever issued of these men and their missions, this is in the "first ever" class of distinction. This category has seen well documented, significant price increases. From the standpoint of future investment value, only 1500 of each print will be made, placing them among the rarest of rare.



Size: (25" x 35") 1" Border

Artist: George Bishop

A HISTORIC COLLECTABLE

Imagine that you and your family for generation after generation will be one of the very privileged few that own either one or both of the commemorative editions signed by the founding fathers of our space program. Also as a *special gift*, a handsome 8 x 10 color portrait of the Mercury 7 team today is included at no charge. We are honored to have this opportunity to share a most collectable and one time only art offering.

ORDER NOW!

These very rare prints are available now on a *first-come first-serve* basis. Your investment price of $285.00 for one or $550.00 for both historic art prints assures your place in history as a privileged owner of this historic and once only signature collection.

RESERVATION

Send Check or Money Order to:
Pacific Coast Galaxy Publishers
P.O. Box 7338, San Diego, CA 92107

- ☐ "Mercury 7" ($285.00 ea. unframed)
- ☐ "Apollo-Soyuz" ($285.00 ea. unframed)
- ☐ "Mercury 7 and Apollo-Soyuz" ($550.00 pair unframed)

- Shipping and insurance included in price.
- California residents add 6.5% sales tax.
- Questions re: ordering call **(619) 224-9629.**

Please include

Name _____

Address _____

City _____

State _____ Zip _____

Allow 3 to 4 weeks for delivery.

GLOBAL CURRENTS

Blue Star Rising

Israel's debut on the satellite circuit

▼ ▼ ▼

By Eric Lee

On the morning of September 19, 1988, bathers on a beach south of the Israeli town of Rishon Lezion were stunned by a sudden roar. Behind the sand dunes, they watched as a Shavit rocket put Israel's first satellite, Ofek-1, into orbit. For the amazed vacationers, Israel's leap into space came as a surprise. For careful observers of the Middle East scene, it was a long-awaited development.

Israel's missile program dates back several decades, but the October 1973 Yom Kippur War was the specific incident that triggered its rapid progress in recent years. The combination of a military intelligence failure on Israel's side and the sophisticated use of Soviet satellite intelligence by the Arabs persuaded many Israeli strategists that it was time to add the power of satellites to Israel's arsenal.

Following Ofek's launch in September, the *Jerusalem Post* speculated that, "had Israel had a surveillance satellite at its disposal in early October 1973...the Yom Kippur War might very well have been preempted." Not exactly; Israel didn't need satellites to see the Egyptian and Syrian troop concentrations on its borders. Furthermore, a single satellite circling the globe every 90 minutes views the area around Israel's borders for only a few moments at a time—leaving long gaps when Arab armies could easily have redeployed. The launch of Ofek was itself delayed by 15 minutes to avoid observation by a satellite passing overhead.

When post-launch speculation centered on possible military implications of Ofek-1, Gerald Steinberg, a former U.S. space expert now based in Jerusalem, declared that a single reconnaissance satellite would be "almost meaningless." Nothing less than an entire system of satellites, costing about $10 billion, would do. But Knesset member Yossi Sarid, an outspoken "dove" when it comes to relations with Arab countries, announced that the deployment of observation satellites meant Israel could now withdraw from the occupied territories without fear of surprise attacks.

The statements of Israeli officialdom shed little light on the country's intentions. Professor Yuval Ne'eman, head of the Israel Space Agency and a leading "hawk," published a lengthy article filled with irrelevancies about the beauty of Jupiter's moons and mankind's destiny among the stars. As for the military value of satellites—not a word. And this from a scientist-politician who formerly headed Israeli military intelligence.

Ofek-1 stayed up for 118 days without a hitch. Its purpose, according to official reports, was merely to test itself: to generate its own solar power (a technology Israel has pioneered), to test the quality of its transmissions from space and its ability to withstand vacuum and weightlessness, and to collect data about the Earth's magnetic fields and the space environment.

Yet this unassuming little satellite attracted world attention. The *London Times* reported that Ofek was an example of a cheap, "pop-up" satellite. It claimed that Israel had developed this technology to use at times of tension in the Middle East, and that satellites like Ofek would transmit pictures live to commanders in the field. Predictably, most Arab commentators denounced the launch as a provocative Israeli move aimed at shifting the strategic balance in the region.

In any event, the psychological impact of Ofek's launch was enormous on both Arabs and Israelis. If more and better satellites follow in years to come, Israel might win the battle for intelligence in the Middle East—a battle as important as any fought with weapons. A satellite system could be linked to the anti-tactical ballistic missile program called "Arrow," which Israel wants to deploy against incoming Arab missiles. It would open up secure communications lines for the armed forces and would improve navigation for Israel's small, high-tech Navy.

But the principal effect of Israel's satellite development is political. Few experts suggest that the planned orbiting of Ofek-2 and Ofek-3 over the next few years will mean the prompt withdrawal of Israeli forces from the occupied territories; as one observer pointed out, the United States didn't close down its Distant Early Warning line in northern Canada just because satellites became available.

If Arab countries deploy their own satellites to counter the Israeli moves, we may yet witness the development of an "open" Middle East: under constant satellite surveillance by both sides, with surprise attacks virtually impossible.

And under those open and clear skies, peace becomes an option both sides might consider. □



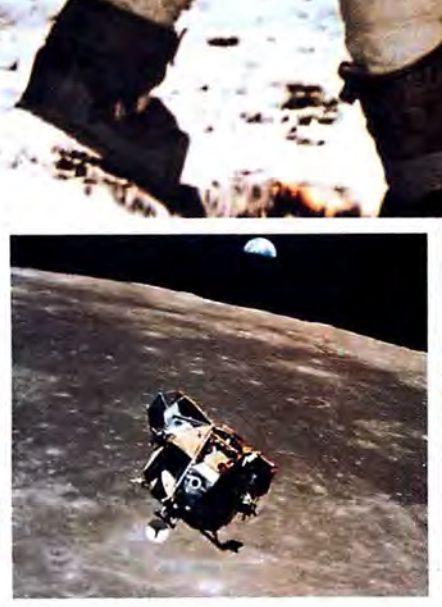
TROY THOMAS

Relive and Preserve America's Proudest Moment!

MEN WALK ON THE MOON

The Video Library of Man's First Landing on the Moon







The 20th Anniversary Collection of Official NASA Films!

© 1989 MBI

Be an Eyewitness to America's Greatest Moment!

Twenty years ago, the whole world watched in awed silence as American astronaut Neil Armstrong took man's first step on the Moon...

Armstrong called it "one small step for man...one giant leap for mankind." Indeed, it may have represented the single greatest achievement in history.

Now, to honor the 20th Anniversary of America's proudest moment, Easton Press Video presents **MEN WALK ON THE MOON**, a spectacular video record of America's triumphant Apollo Moon missions.

Experience the Breathtaking Drama!

In these three hours of stunning Official NASA films, you will relive every major event in the race to the Moon. You'll see and own the complete video record — including films and footage never before available in a home video collection!

You'll experience the human drama of the American astronauts. The incredible scientific breakthroughs. The drive and daring of an entire nation committed to a dream.

Included are breathtaking Moon and Earth views from space, heartstopping launches and recoveries, riveting picture transmissions to Earth, the historic footage of Armstrong and Aldrin on the Moon, and more! Here is the complete story of America's Apollo Moon missions — brilliantly narrated, sensationally filmed.

Attractively Priced — Convenient Monthly Installments

The entire library — three videos, 3 hours — comes in a handsome library case and is affordably priced at only **$24.95* per video.** You pay for only one video per month. Satisfaction guaranteed or return within 15 days for a full refund. Order today! For yourself, for your family, for future generations!

*plus $3.75 shipping/handling per set.



RESERVATION APPLICATION

Easton Press Video
47 Richards Avenue
Norwalk, Conn. 06857

Satisfaction Guaranteed.

For Fastest Service Call Toll-Free 1-800-367-4534
In Conn. call 1-855-8717

Yes! Please send me the MEN WALK ON THE MOON video library. I understand only VHS format is available.

Name _____
PLEASE PRINT CLEARLY

Address _____

City _____

State/Zip _____

Signature _____ (All orders subject to acceptance.)

Charge each of 3 monthly installments of $26.20* each to my credit card: ☐ VISA ☐ MasterCard ☐ American Express ☐ Diners Club

Credit Card No. _____ Exp. Date _____

☐ I prefer not to use a credit card and will pay by check. Enclosed is my deposit of $26.20*. I will pay the balance as billed in two monthly installments of $26.20* each.

Allow 6 to 10 weeks for shipment.
*Includes shipping/handling. CT residents add 7½% sales tax.

MISSION FILE

STS-30



LAUNCH:
2:46 P.M. EDT, May 4, 1989, Pad 39B, Kennedy Space Center, Florida
LANDING:
12:43 P.M. PDT, May 8, 1989, Edwards Air Force Base, California
ORBITER: Atlantis
ALTITUDE:
160-177 nautical miles
CREW:
David M. Walker, Commander
Ronald J. Grabe, Pilot
Norman E. Thagard, Mary L. Cleave, Mark C. Lee, Mission Specialists
PRIMARY PAYLOAD:
Magellan Radar Mapper
OTHER PAYLOADS:
Fluids Experiment Apparatus
Mesoscale Lightning Experiment

"Venus or Bust"

The banner in shuttle launch control neatly summed up the goal of the STS-30 flight: To send the Magellan radar mapping spacecraft rocketing toward its August 1990 rendezvous with Venus. Magellan was NASA's first planetary mission in more than a decade, and the first ever to be launched from the shuttle.



The crew of Atlantis (left to right: Thagard, Grabe, Cleave, Walker and Lee) poses for a group portrait on the flight deck.

DAY 1

Liftoff was delayed for nearly an hour while NASA managers waited anxiously for threatening clouds to dissipate and for crosswinds at the shuttle's Kennedy Space Center runway to subside. Atlantis finally beat both the weather and the clock, roaring away from Pad 39B with only five minutes left in its launch window for May 4.

Just over six hours into the flight, astronaut Mark Lee sent the command to push Magellan and its Inertial Upper Stage (IUS) booster out of the orbiter's cargo bay. Looking like some impossibly large Tinkertoy in TV pictures relayed to Earth, the spacecraft floated silently up and away from Atlantis, while the sparkling blue-and-white Earth rolled by like a painted backdrop below. After two successful IUS engine burns an hour later, Magellan was headed toward Venus and functioning flawlessly.

Following the deployment, Atlantis' five-person crew had only a few minor hardware problems to cope with. One of the orbiter's maneuvering thrusters had failed during ascent (ground controllers predicted no impact on the flight), and a printer for the Text and Graphics System, a high-tech fax machine, became hopelessly jammed with paper when it was activated.

DAY 2

The weight of the Magellan/IUS (more than 45,000 pounds combined) and the extra maneuvering fuel needed to position the spacecraft properly in orbit left Atlantis' astronauts with a lighter-than-usual roster of secondary experiments to perform. Mark Lee and Mary Cleave cranked up the Fluids Experiment Apparatus, a device to obtain pure crystals in zero-g. The FEA uses a heater to produce a "melt zone" as it moves along a length of sample material. Any impurities tend to stay in the melt, to be deposited at the end of the sample at the close of the experiment.

Cleave noted that the firing of Atlantis' attitude thrusters appeared to disturb processing of an iridium sample. For as long as five minutes afterwards, she reported, there were "little pressure waves in the melt."

The astronauts searched for thunderstorms as part of the Mesoscale Lightning Experiment, an effort by scientists to understand better the propagation of lightning discharges over a large geographical area. In addition, Mission Control requested that the crew photograph an oil spill from a supertanker off the Saudi Arabian coast.

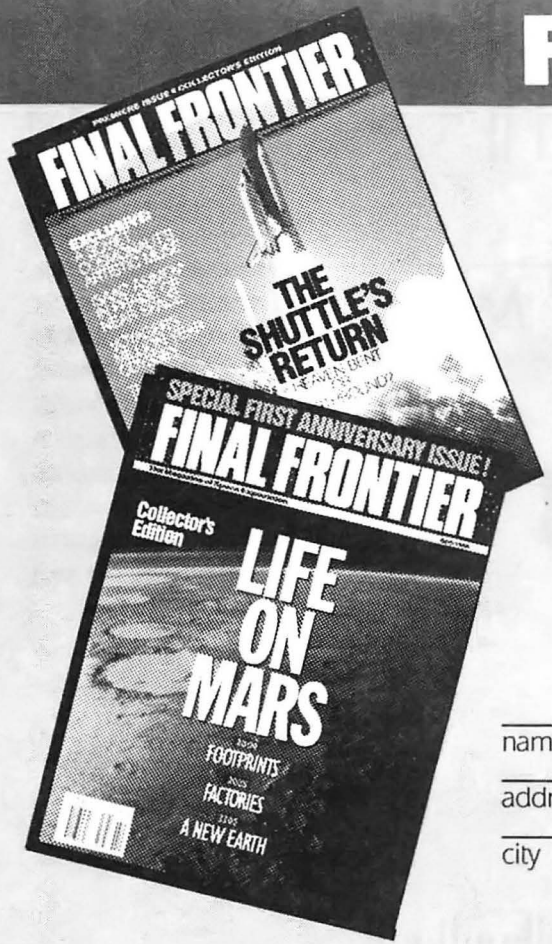
The astronauts also performed several engineering tests and biomedical studies. Searching for the proper screwdriver to fix a balky piece of medical equipment, mission commander Dave Walker and pilot Ron Grabe looked and sounded like two guys working in a garage back home. "The good news is that it now reads '000'," radioed Grabe. "The bad news is that it reads nothing *but* '000'."

DAY 3

After awakening to a medley of their respective college fight songs, the astronauts continued working with the FEA and conducted additional secondary experiments. Norm Thagard and Mark Lee verified that their launch and entry suit helmets could be used to pre-breathe oxygen in preparation for spacewalks. Dave Walker and Ron Grabe also maneuvered Atlantis to support tests of sensors at the Air Force Maui Optical Site (AMOS) in Hawaii.

The highlight of Atlantis' third day in space was a televised tour of the orbiter's

FINAL FRONTIER



We go where no magazine has gone before...

Space enthusiasts all over the world have discovered FINAL FRONTIER— the magazine with a mission to advance space exploration. FINAL FRONTIER does more than report — it stirs the imagination. In every issue you'll learn about the past, present and future of humanity's greatest adventure — the exploration of space. The final frontier.

Join us...subscribe today!

1 year $14.95
(6 issues)

Save 29%

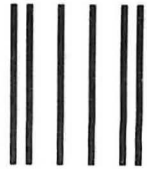
☐ Payment enclosed ☐ Bill me

name

address

city state zip BBH9S

Please allow 4-8 weeks delivery. Canadian rate $19.95, all other countries $23.95. Payment in U.S. currency must accompany all foreign orders.



NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES



BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 89016 Escondido, CA

Postage will be paid by addressee

FINAL FRONTIER

P.O. Box 3803
Escondido, CA 92025-9561



cabin conducted by Mark Lee. The space "rookie" used a commercial 8mm camcorder to send back views of the astronauts' personal mementoes (including a photo of one of Lee's Angus cows) mounted on the mid-deck walls, and breathtaking shots of the Earth taken from Atlantis' large flight deck windows.

DAY 4

The mission's only significant problem occurred when one of Atlantis' general purpose computers suffered an irreparable hardware failure. Using preplanned procedures during a four-hour work session, Mark Lee, Norm Thagard and Mary Cleave unscrewed a maze of cables and connectors, then replaced the faulty unit with a spare computer routinely carried on shuttle flights. The effort scrubbed most of the day's scientific activities, including the last sample run in the FEA, and forced the crew to stay up an extra hour or so stowing gear in preparation for the next day's return to Earth.

Noting that a computer changeout is one of the most difficult in-flight maintenance procedures on the shuttle, flight director Milt Heflin praised the astronauts' efficiency. "Just another day in the office," he quipped.

DAY 5

As Atlantis sailed tail-first over the Indian Ocean, the crew fired the orbiter's maneuvering engines to begin the hour- long descent to Edwards Air Force Base.

Flight controllers had hoped for light winds blowing across the dry lake runway at Edwards; one of the mission's objectives was to test the shuttle's handling qualities in a crosswind landing. When the winds became *too* strong, however, the orbiter's landing site was switched in a hurry to Edwards' concrete Runway 22. Mission Control radioed the change in plans to Commander Dave Walker just 13 minutes prior to touchdown, as Atlantis streaked through the atmosphere at Mach 13.



Just over six hours into the flight, Magellan and its attached booster rocket were sprung from the shuttle's cargo bay. An hour later, the probe started out on the 15-month trek to Venus.

The 27,000 people who had gathered at the planned landing site far from Runway 22 saw little of Atlantis as Walker and Ron Grabe guided the spaceliner to a smooth touchdown in a gentle crosswind. CAPCOM Frank Culbertson congratulated the crew as Atlantis rolled to a stop.

"You've extended the shuttle's reach far beyond Earth orbit," crowed Culbertson. "Commodore Magellan would approve."

Only a handful of Atlantis' protective tiles were damaged during the flight, and the spaceplane appeared in excellent shape to undertake its next mission in October: the launch of the Galileo spacecraft on its six-year trek to Jupiter.

BOUNDARIES

In Search Of The Big Bang

COBE attempts to solve the ultimate riddle.

▼ ▼ ▼

By Henry Fuhrmann

In this year of high-profile space science missions, a relatively obscure NASA satellite will address the biggest question of all: Where did it all begin?

The Cosmic Background Explorer is slated to embark July 20 on a year-long search for the echo of the Big Bang, the cataclysmic explosion in which the universe is believed to have begun some 15 billion years ago.

COBE—pronounced "co-bee"—will share a crowded space science stage this year. The long anticipated launches of Magellan, Galileo and the Hubble Space Telescope will compete for top billing with Voyager 2's flyby of Neptune. Even without those missions stealing most of the spotlight, COBE may find its own send-off overshadowed: Its scheduled launch date coincides with the 20th anniversary of the first Apollo lunar landing.

To those who deal with such questions, however, COBE will mark a major advance in efforts to determine the universe's origins. The Big Bang is, after all, only a theory, and like all theories it includes a fair amount of uncertainty.

Although the great majority of astronomers accept the idea, said Nancy Boggess, COBE's deputy project scientist, "There is very little observational evidence to show that the universe did begin with a Big Bang."

Discoveries early in this century gave rise to the theory— most notably Edwin Hubble's finding that the galaxies are receding from each other at great speed, like the cosmic debris of a giant explosion. For many theorists, the clinching evidence came in 1964, when two Bell Laboratories scientists discovered the so-called cosmic background radiation. This presumed remnant of the Big Bang appears uniformly throughout space in every direction from Earth. It has cooled from initial temperatures of trillions of degrees to a frigid 3 degrees above absolute zero as it has spread out over the vastness of the cosmos.

Convincing as that discovery may be, the evidence for the Big Bang is at best circumstantial, and that's where COBE comes in. From its vantage point 560 miles above the Earth, circling near the poles, the satellite will conduct two complete scans of the sky over the course of a year. COBE will take continuous measurements of the cosmic background, which is obscured by the Earth's atmosphere and therefore has only been studied from mountaintops, balloons or rockets.



COBE may learn whether the universe began with a bang or with a whimper.

COBE's trio of detectors will try to determine whether the cosmic background is as uniform as previous measurements make it out to be. Are the brightness and temperature really the same everywhere we look? Even slight deviations would mean major changes in cosmological thought.

Should COBE's microwave radiometer find variations in brightness, Boggess said, they could be signs that matter began clumping together shortly after the Big Bang. That in turn could explain the subsequent formation of galaxies and other large-scale structure in the universe, which the Big Bang theory has trouble accounting for.

Any differences COBE finds between the radiation's spectrum and predicted values could indicate the presence of early energy sources other than the Big Bang expansion itself. To cite one example, Boggess said, black holes could have swallowed up great quantities of matter and released energy that would be visible to COBE's spectrophotometer. The satellite's diffuse infrared background experiment may even be able to find a faint glow coming from a previously unseen first generation of stars and galaxies.

Planning for COBE began 15 years ago at NASA's Goddard Space Flight Center in Greenbelt, Maryland, which manages the long and successful series of Explorer spacecraft. Like many recent space agency projects, the road to the launch pad has been bumpy. COBE was originally designed for launch from the shuttle's payload bay; after the Challenger disaster, it had to be redesigned for a Delta booster. The new COBE is leaner by some 5,000 pounds, half its original weight, without sacrificing any of its scientific payload.

As launch day approaches, COBE scientists have a lot to look forward to. Recent rocket-borne studies by American and Japanese researchers have detected excess radiation at previously unprobed wavelengths of the cosmic background. The full impact is not yet known, Boggess said, "but if it is really there, then COBE will see it."

More generally, she said, "COBE is not designed to prove or disprove any particular theory. It is to give us the first observational evidence in a very sensitive, complete fashion, so that people can then use these data to understand what constraints need to be put on the theories.

"What we're really trying to do," she adds, "is produce a definitive spectrum of the cosmic background—and let the chips fall where they may." □

Does exploring other worlds make your heart beat faster?



Help launch a new era in planetary exploration... and enjoy the many benefits of membership in The Planetary Society.

This is an important time for space exploration enthusiasts like you. At no other time in history has the exploration of other worlds held more promise. Through your membership in The Planetary Society, *you* can help fulfill this promise...*you* can have an impact on the exploration of other worlds and the search for extraterrestrial intelligence.

In the last two decades, for the first time in history, we have studied our neighboring worlds close up and in detail—the enigmatic pyramids of Mars, the organic clouds of Titan, the 10,000 Saturnian rings. Right now, the U.S., the U.S.S.R., the European Space Agency and Japan are planning historic space missions. These epic ventures will be remembered by our descendants thousands of years from now when most other achievements of our time will be forgotten.

See the universe in a new light

The Planetary Society, as the world's largest, most influential space interest group, will have an impact on such programs. And you, as a Planetary Society member, will be a part of our efforts. As a member, you not only take a front-row seat in the ultimate adventure in space. Your membership will actually help move ahead international programs to explore the cosmos...will actually help finance the radio search for extraterrestrial intelligence.

Headed by some of the world's most distinguished scientists, The Planetary Society provides more than 100,000 members with knowledge and inspiration that sparks their imaginations and keeps them on the cutting edge of space exploration.

U.S. Planetary missions scuttled. New hopes for new missions.

Since 1978, the U.S. has not launched a single mission to the planets—after dozens of historic missions in the preceding two decades. Today, The Planetary Society is spearheading efforts to renew U.S. commitment to missions awaiting launch: *Galileo, Magellan, Ulysses* and *Mars Observer.* And we are disseminating information to the American people on the ambitious Soviet *Phobos* mission and on future Soviet Mars exploration. We are also leading the drive for a multinational piloted mission to Mars and new expeditions to other planets. We invite you to join us.

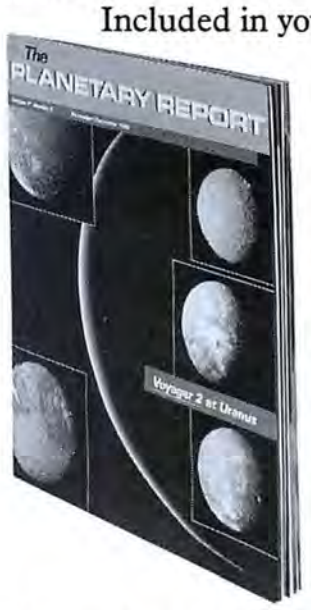
Many membership benefits.

There's no other organization like The Planetary Society. When you join, in addition to receiving our colorful magazine *The Planetary Report* six times a year, you'll get special discounts on books, videotapes, posters, prints and other materials. You'll also be invited to special Society events and activities, such as Planetfest '89.

6¢ a day is all it takes!

To become the next member of The Planetary Society, just fill out the Membership Form below and return it right away. Send no money now. We'll bill you for your low membership dues of just $20* a year. That's about 6¢ a day to take part in this unique adventure.

Included in your membership...



The Planetary Report

Lively, authoritative coverage of planetary exploration delivered to you bimonthly. The most comprehensive accounts of discoveries about other worlds. First-hand reports from scientists of many nations. Full-color photographs from space. Not available on newsstands. Sent to you as a member of The Planetary Society.

For more information: call 1-800-255-2001

SEND NO MONEY NOW



Co-founders of The Planetary Society: Bruce Murray, Professor of Planetary Sciences, California Institute of Technology (seated left); Carl Sagan, Director, Laboratory for Planetary Studies, Cornell University (seated right); Louis Friedman, Executive Director (standing).

Yes, enroll me as a new member of The Planetary Society.

Send my membership card, start *The Planetary Report* coming to me and bill me just $20* for my first year's dues. Be sure to send me invitations to the Society's special events and activities.

Guarantee: You may cancel at any time and receive an immediate refund for the balance of your membership year.

Name_____

Address_____

City_____

State_____ Zip_____

*Canadian memberships are $30 (Canadian dollars) and foreign memberships are $30 (U.S. funds) per year.

THE PLANETARY SOCIETY

65 North Catalina Ave., Pasadena, CA 91106-9899

AA10

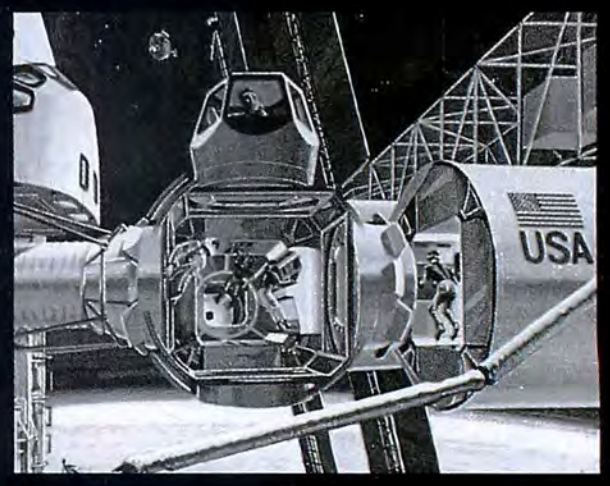
Windows on the World

Space station Freedom's "cupolas" will offer new vistas on heaven and Earth.

BY ALCESTIS R. OBERG







Freedom's cupolas (shown in mockup, left and center) will provide a spectacular perch for Earthgazing astronauts. They also will serve as the station's nerve center and (right) as a control tower for shuttle dockings.

The view is breathtaking, if a little bit odd. In Earth terms, the astronaut is hanging upside down like a bat, watching the world silently go by from a small, cozy perch jutting downward from the far end of space station Freedom, just beneath the shuttle docking port.

After long hours struggling with balky experiments, the tired crew member retreats to this 12-windowed "cupola" overlooking the Earth to experience the beauty of an orbital sunrise—a stereoscopic explosion of light that illuminates Freedom's girders and modules.

As the cupola is flooded with the Sun's bold brightness, the view downward is so unobstructed that the astronaut instinctively grips the nearby handholds. It's easy to forget the day's troubles and remember the reason for becoming an astronaut in the first place—to be here, to see this.

The "eyes" of NASA's orbiting outpost of the 1990s will be a unique new kind of space structure with a quaint, old-fashioned name: cupola. Like the weather-vaned chimneys atop country barns, space station cupolas will have the best view available of the surrounding neighborhood.

The ideal structure for a panoramic view of space would be a giant glass dome similar to the navigation "bubbles" that long-range aircraft used to carry. But a glass bubble in space would be an accident waiting to happen. One small puncture from a piece of orbital debris could cause sudden decompression, and the dome would explode like a bomb.

So designers of the space station cupola have fallen back on tried-and-true flat windows, arranged on an octagonal framework—four windows on top, and eight around the side. From inside, the view is something like being inside a fly's eye.

Two cupolas are planned for Freedom: one "Earthside," with a view of the underside and lower booms of the station, and the other on top, with a view of the upper part of the structure as well as the stars.

Two people can fit inside each cupola if they stand shoulder-to-shoulder. The current mockup at NASA's Johnson Space Center, built by space station contractor McDonnell Douglas, is about six feet tall. With an adaptor connecting it to a hatchway in one of Freedom's resource "nodes" (short sections linking the larger cylindrical modules), an astronaut could squeeze his or her entire body inside the cupola, and still be able to close the hatch. Other designs for a shorter cupola would accommodate astronauts only from the waist up, with their legs dangling down into the node.

Despite the spectacular view, sightseeing will be only an incidental activity inside the cupolas, which are the primary nerve centers for monitoring the exterior of the station and the space around it. Whatever operations are happening outside the station, astro-

continued on page 68



THE FUTURE *as it was*

Back in the 1950s, Von Braun & Co. had a grand space program ready to go. All it would take was time and money.

By Les Dorr, Jr.

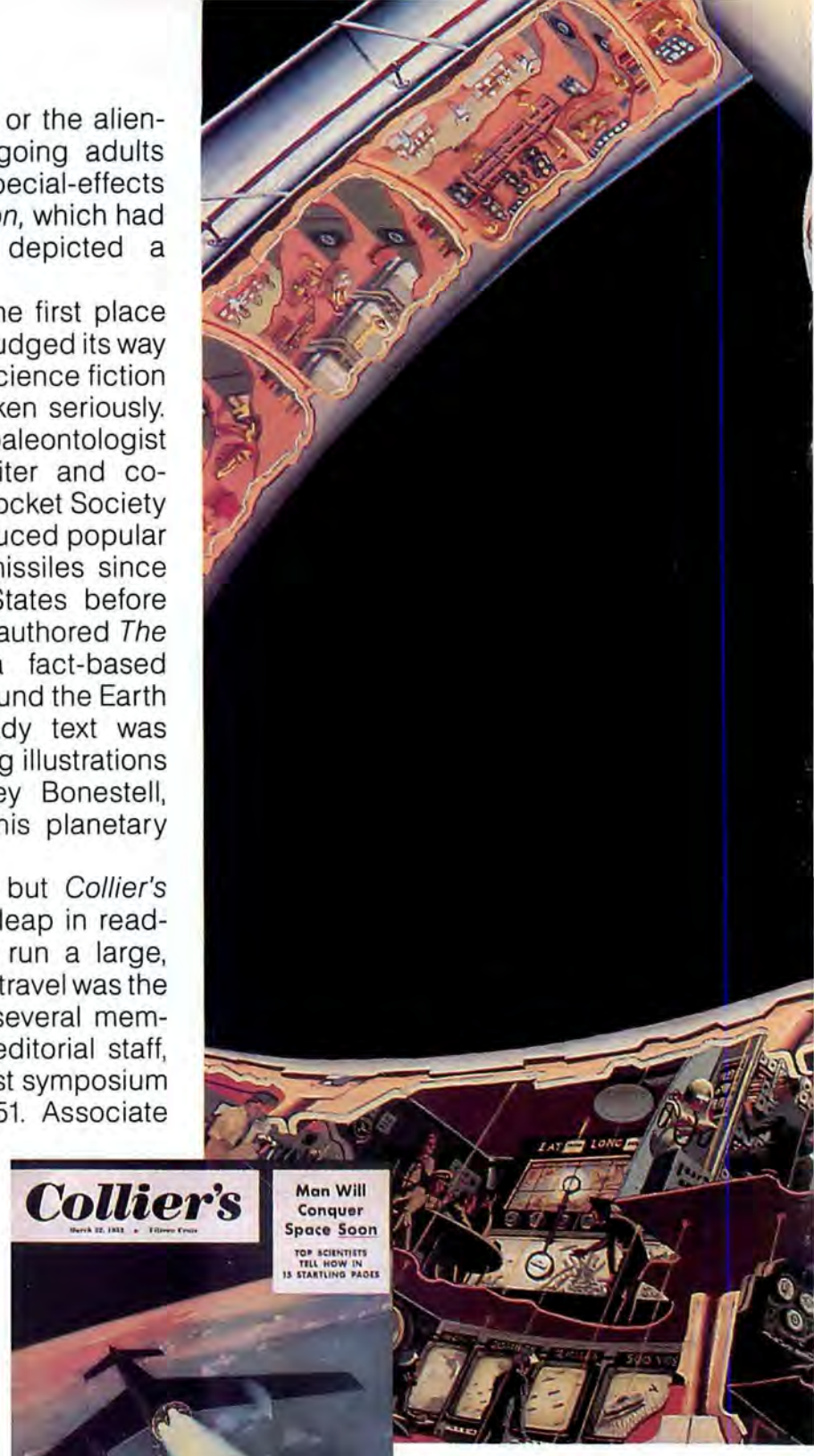
When *Collier's* magazine hit the stands on March 22, 1952, many of the weekly's loyal readers probably did a quick double take. In place of the usual fluffy cover art, a sleek black rocket ship blasted its way into the heavens, leaving a spent, glowing booster stage behind. "MAN WILL CONQUER SPACE SOON" the cover blurb proclaimed urgently, adding that "Top Scientists" would explain it all in "15 Startling Pages."

Inside, rocket *wunderkind* Wernher von Braun and science popularizer Willy Ley laid out a vision that was fantastic for those pre-Sputnik days: an orbiting wheel-shaped space station crewed by 80 people...a mammoth launch vehicle with *28 million* pounds of thrust...astronauts zipping back and forth in "space taxis." Just give us, they said, ten years and four billion bucks—about a quarter of the Defense Department budget for 1951—and *pax Americana* will reach outward to the stars.

As a nation, we were already becoming space-happy. Kids vegetated in the baleful light of the TV tube as the stalwart heroes of *Tom Corbett, Space Cadet* and *Space Patrol* efficiently dispatched galactic villains or the alien-of-the-week. And moviegoing adults had goggled at the special-effects magic in *Destination Moon*, which had realistically (for 1950) depicted a piloted lunar flight.

Collier's wasn't even the first place where space travel had nudged its way out of the realm of pulp science fiction and demanded to be taken seriously. The same Willy Ley—a paleontologist by training, science writer and co-founder of the German Rocket Society by avocation—had produced popular books on rockets and missiles since coming to the United States before World War 2. In 1949, he authored *The Conquest of Space,* a fact-based blueprint for voyages around the Earth and beyond. Ley's heady text was punctuated by the striking illustrations of cosmic artist Chesley Bonestell, already well-known for his planetary landscapes.

Ley's book sold well, but *Collier's* represented a quantum leap in readership. The decision to run a large, colorful spread on space travel was the collective brainchild of several members of the magazine's editorial staff, who had attended the first symposium on the topic late in 1951. Associate editor Cornelius Ryan, who later wrote *The Longest Day* and other popular accounts of World War 2, was assigned to coordinate the project.



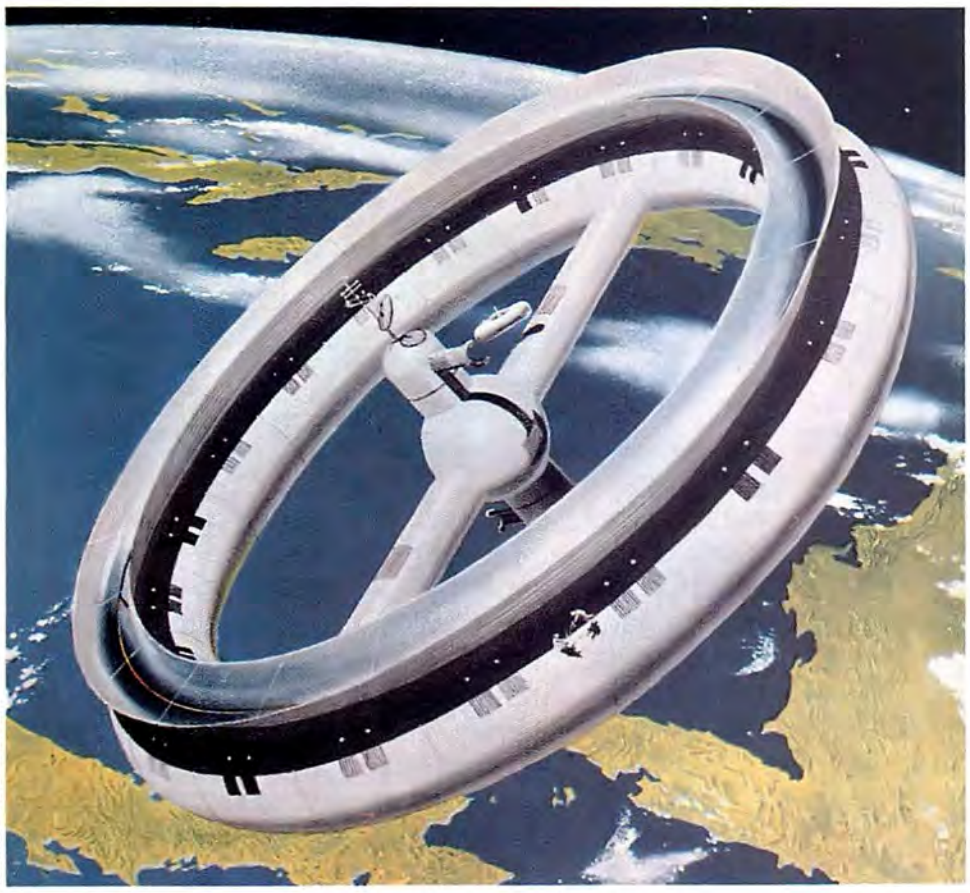
In "Crossing the Last Frontier," Wernher von Braun described a typical orbital flight aboard a winged shuttlecraft. He packed an enormous amount of detail into a six-page article: specifications for a 240-foot-tall rocket booster, possible launch sites (one was "the Air Force Proving Ground at Cocoa, Florida,", later and better known as Cape Canaveral) and speed and altitude checkpoints along the vehicle's flight path.

Von Braun had his proto-shuttle rendezvous with a 250-foot- wide inflatable space "wheel" spun to produce artificial gravity. In a separate article, Ley described the minutiae of the station's interior, relating how astronauts would live and work "under conditions comparable to those on a modern submarine." A third feature by Heinz Haber of the Air Force School of Aviation Medicine was a primer on the biomedical hazards that would be faced by space voyagers. Despite the unknowns, Haber wound up on a positive note: space travel would probably be safer than "crossing a busy street at rush hour."

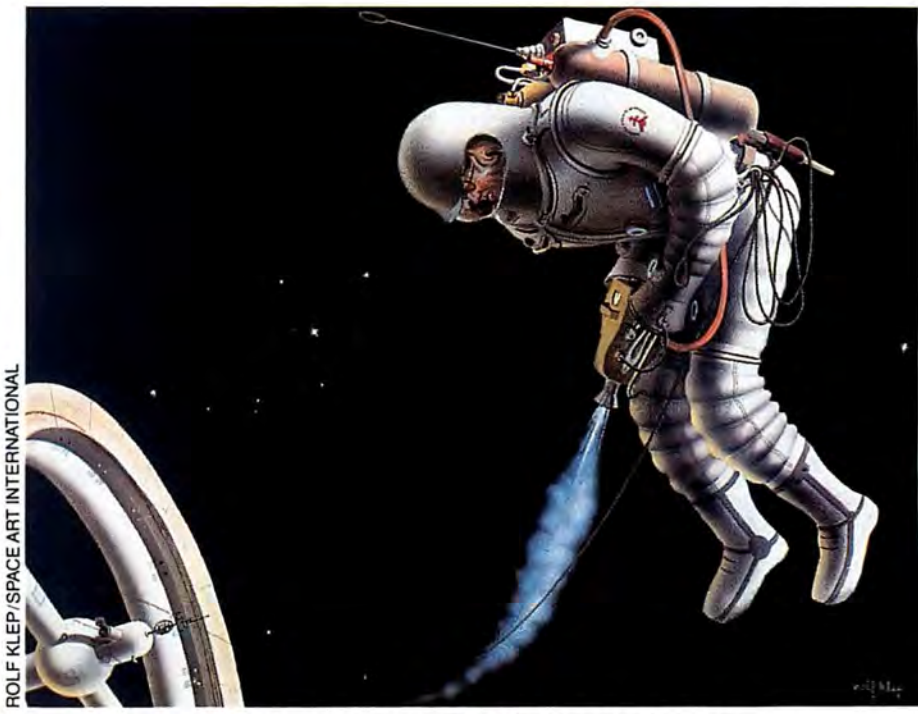
Later astronauts would sail off into the heavens "for all mankind," but there was no altruism behind the *Collier's* articles. The Korean War was still raging, and Americans were looking for a Red under every bed. The magazine's editors warned that if the United States declined to secure "space superiority," it faced the specter of a "ruthless foe"—read Stalin's Soviet Union—ensconced on an orbiting battle station, from which it could "subjugate the peoples of the world." Von Braun himself echoed that sentiment, casually noting that a space station would make "a terribly effective atomic bomb carrier."

Collier's brought Ley and von Braun back for an encore in October 1952.

FRED FREEMAN/SPACE ART INTERNATIONAL



CHESLEY BONESTELL



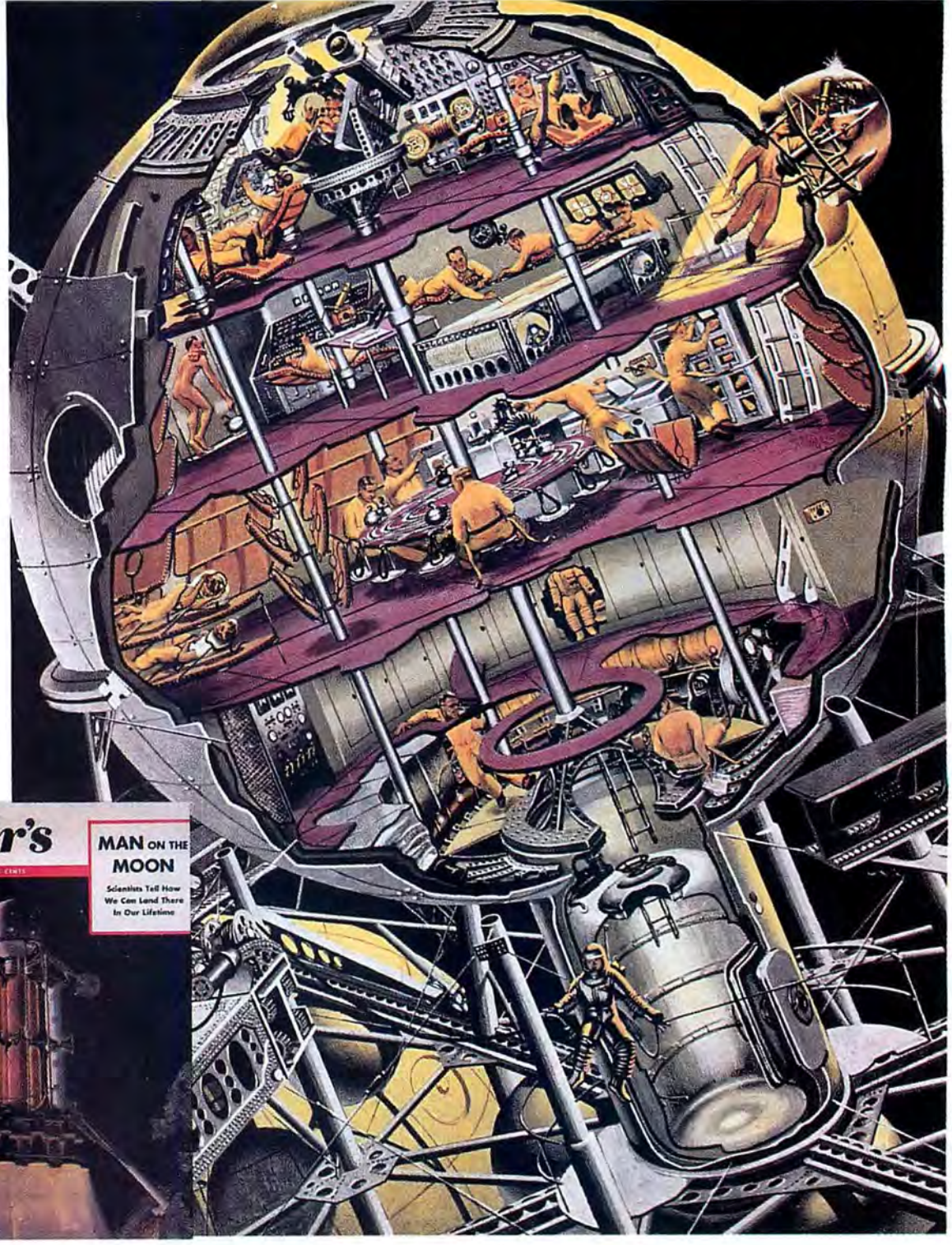
ROLF KLEP/SPACE ART INTERNATIONAL

Sound familiar? A large, Earth-orbiting space station (left, and cutaway at top) was von Braun's stepping-stone to the Moon and Mars. He also envisioned astronauts zipping through space with hand-held maneuvering units (above).

Willy Ley's Moon ship (right) included bath stalls and microwave ovens. (Below) Chesley Bonestell's lush artwork depicting a Mars expedition.

With the Red Menace presumably Earthbound and under control, it was time to conjecture about one of humanity's oldest dreams—a landing on the Moon.

Today, the grand scope and audacity of von Braun's first lunar expedition seem almost comical. Ever the dreamer, von Braun postulated a crew of *fifty* astronauts, aboard three great spidery Moonships built in Earth orbit over a period of months, who would land in the northernmost part of the Moon's Ocean of Storms by 1977. Scientist and engineer von Braun kept his explorers busy: During a six-week stay, they tore down their cargo ship to construct a base, chugged off in Moonbuggies to scout an area the size of the northeastern United States, and scaled the rim of Harpalus crater. As a finale, a solitary Moonwalker was lowered—by rope—11,000 feet to the crater floor.

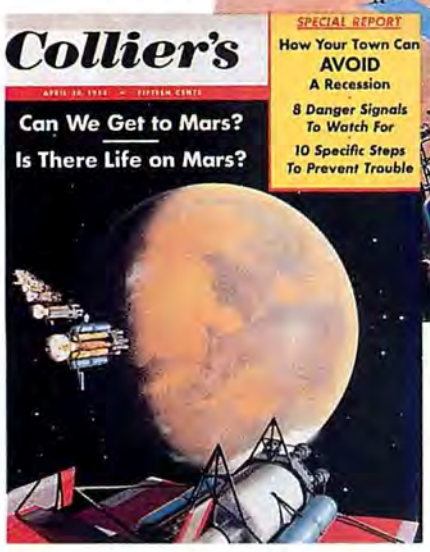


FRED FREEMAN

Once again, Ley tackled the technical description of the astronauts' home away from home. On the Moon-bound spacecraft, his passengers ate frozen foods zapped in a microwave and took sponge baths in a stall (*a la* Skylab of two decades later). His lunar base was less visionary. Except for the solar-heated mercury vapor power generator, Ley might have been describing an early 1950s Antarctic camp.



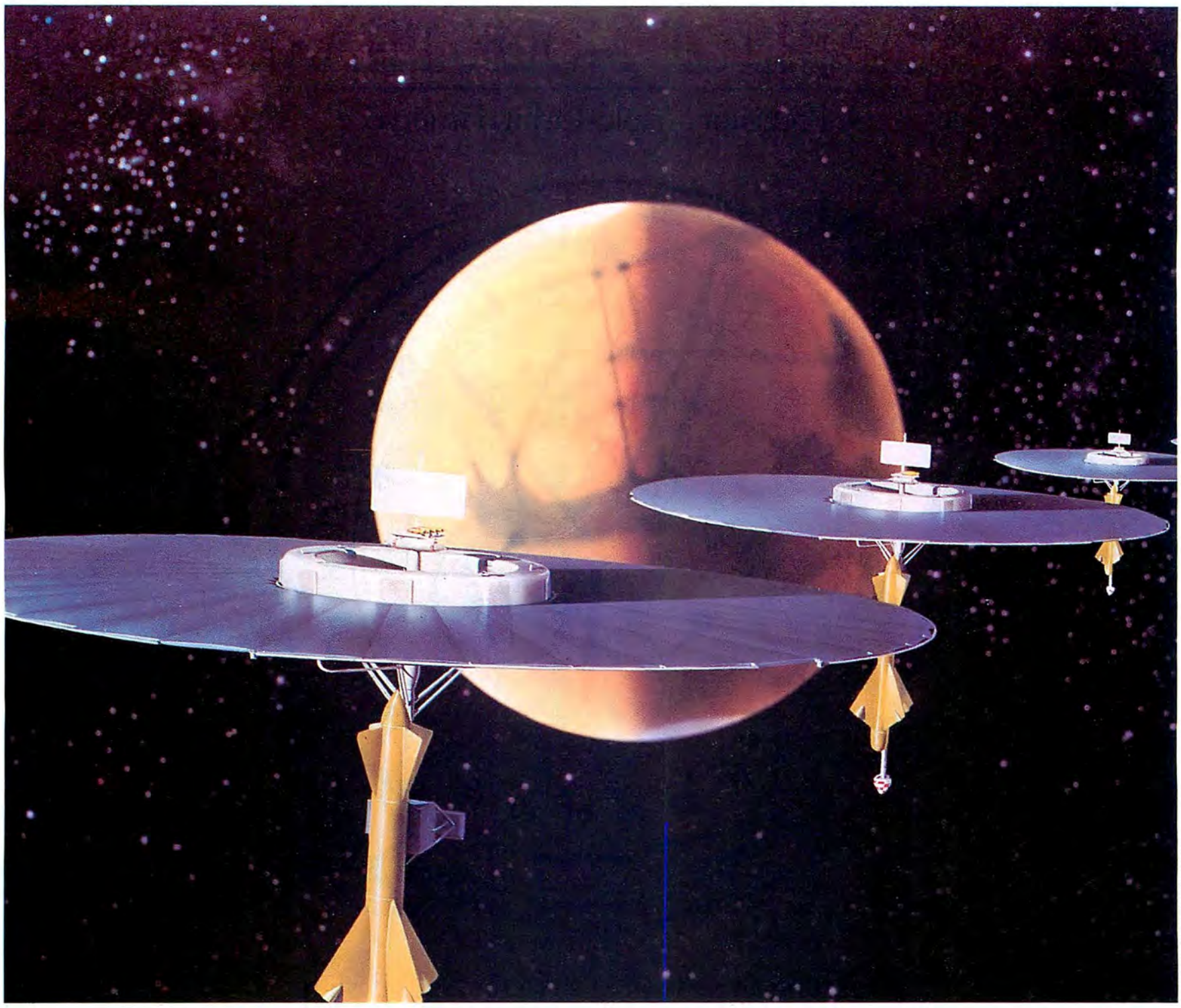
CHESLEY BONESTELL/SPACE ART INTERNATIONAL



Not everyone was quite as ready to jump on the futuristic bandwagon as *Collier's*. Noted space historian Frederick C. Durant III, then vice president of the American Rocket Society, recalls that one major rocket company passed the word it would withdraw corporate sponsorship "if the Society didn't stop all this 'foolishness' about spaceflight." And in announcing Arthur C. Clarke's nonfiction treatise *The Exploration of Space* as one of its July 1952 selections, the Book-of-the-Month Club felt compelled to assure members it hadn't gone nuts. The group admitted the offer of Clarke's book might seem "a fantastic gesture" to its level-headed members; certainly the judges had never made "an odder choice," but they hoped readers would find it "rewarding."

Collier's returned to space, so to speak, in the spring of 1953 with a three-part series on the human aspects of rocket-powered flight. There were no dramatic bylines this time, but editor Cornelius Ryan drew on material provided by von Braun, Ley, James Van Allen (discoverer of the eponymous radiation belts) and aerospace medical experts such as the Haber brothers, Heinz and Fritz.

In successive weeks, the articles



THE WALT DISNEY COMPANY

spelled out the process of selecting and training the brave young men who would fly into space. And yes, there was even a place for women as radio and radar operators, *Collier's* noted, because they had demonstrated the ability to "perform monotonous tasks ... without undue loss of efficiency."

This was six years before the original Mercury astronauts were chosen, yet *Collier's* qualifications for space flyers epitomize nearly all the Right Stuffers: age between 28 and 35, with medium build; height, 5′5″ to 5′11″, with a college degree or equivalent.

The 1953 series on making a "space man out of an Earth man" may have lacked the daring and originality of the earlier articles, but *Collier's* didn't disappoint its fans the following year. Timed for the closest approach of Mars in 13 years, the last of the magazine's classic features reunited von Braun's straightforward prose with Chesley Bonestell's stunning visuals to paint a



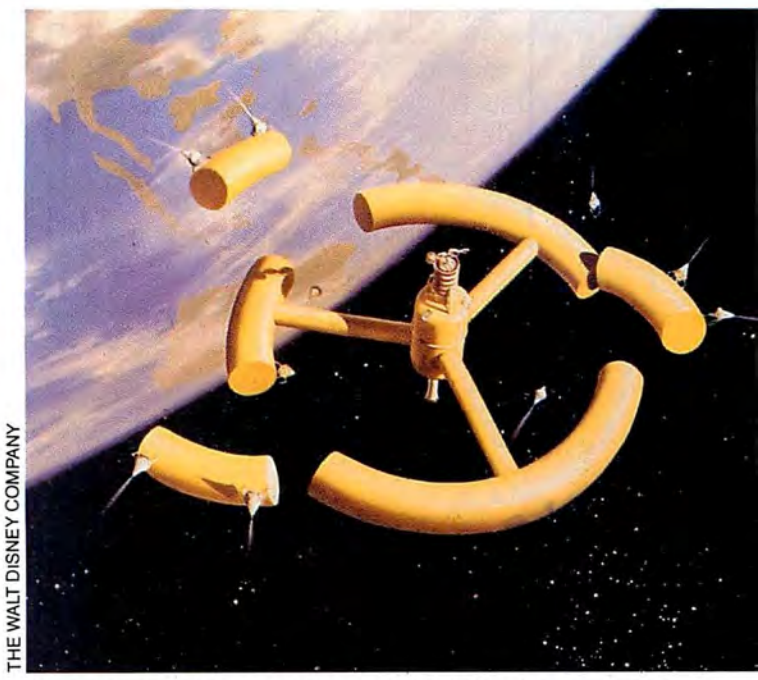
THE WALT DISNEY COMPANY

realistic portrait of a 21st Century voyage to the Red Planet.

Mars and von Braun were old friends. Even as he helped the U.S. Army shoot off captured V-2s during the late '40s, the German rocket pioneer had minutely planned a "Marsprojekt" to send ten spaceships and 70 astronauts on an excursion to survey the Martian surface.

Von Braun drew heavily on his study (published in English in 1952 as *The*

continued on page 64

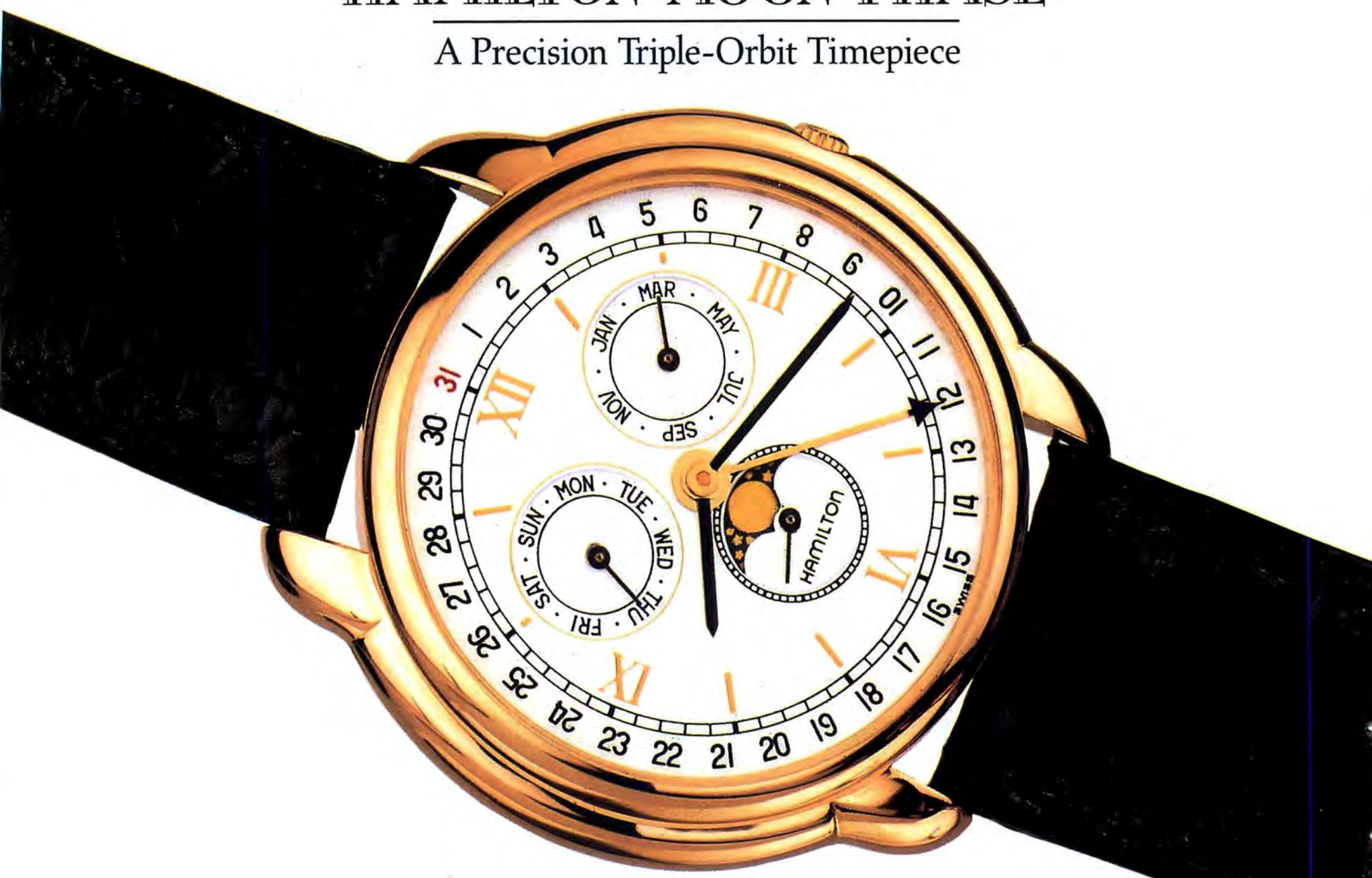


THE WALT DISNEY COMPANY

Walt Disney (second from right) hired von Braun, Ley and Heinz Haber to bring their visions to television. Millions of viewers watched astronauts assemble a space station (above) and a space fleet sail for Mars (top).

HAMILTON MOON-PHASE

A Precision Triple-Orbit Timepiece



Stunning adaptation of a classic 1940s design.

A prestigious timepiece for people whose time is precious...the Hamilton Moon-Phase is brilliantly updated for the demanding style of the 1980s.

Its intricate triple-orbit design makes a striking fashion statement in any setting and is the height of elegance for every occasion.

The precision analog displays track the month, day, date, hour, minute and second, as well as the phases of the moon. All kept to pinpoint accuracy by a state-of-the-art Swiss quartz movement.

Each Hamilton Moon-Phase is richly finished with 5 microns of 18k gold and fitted with a genuine crocodile wrist band.

Flawlessly built *by hand* by the craftsmen of the world famous Hamilton Watch Company, the Moon-Phase is offered to you for just $295,* payable in convenient monthly installments.

As an added luxury, your Hamilton Moon-Phase will be engraved on the back with up to three initials of your choice, at no additional charge.

Order now to avoid disappointment. If you are not completely delighted, return your watch in original condition within 30 days for a full refund. Phone orders shipped within 5-7 business days.

*Plus $3.50 shipping/handling.

©1989 MBI

Call Toll-Free: 1-800-367-4534

Hamilton® Classics
47 Richards Avenue
Norwalk, Conn. 06857

8351

For Fastest Service Call Toll-Free: 1-800-367-4534

Please send me _____ Hamilton MOON-PHASE watch(es).

Initials to be engraved on back: ☐ ☐ ☐

Charge each of 8 installments of $37.31 each to my credit card:

☐ MasterCard ☐ VISA ☐ Diners Club ☐ American Express

Credit Card # Expiration Date

Name _____
PLEASE PRINT CLEARLY

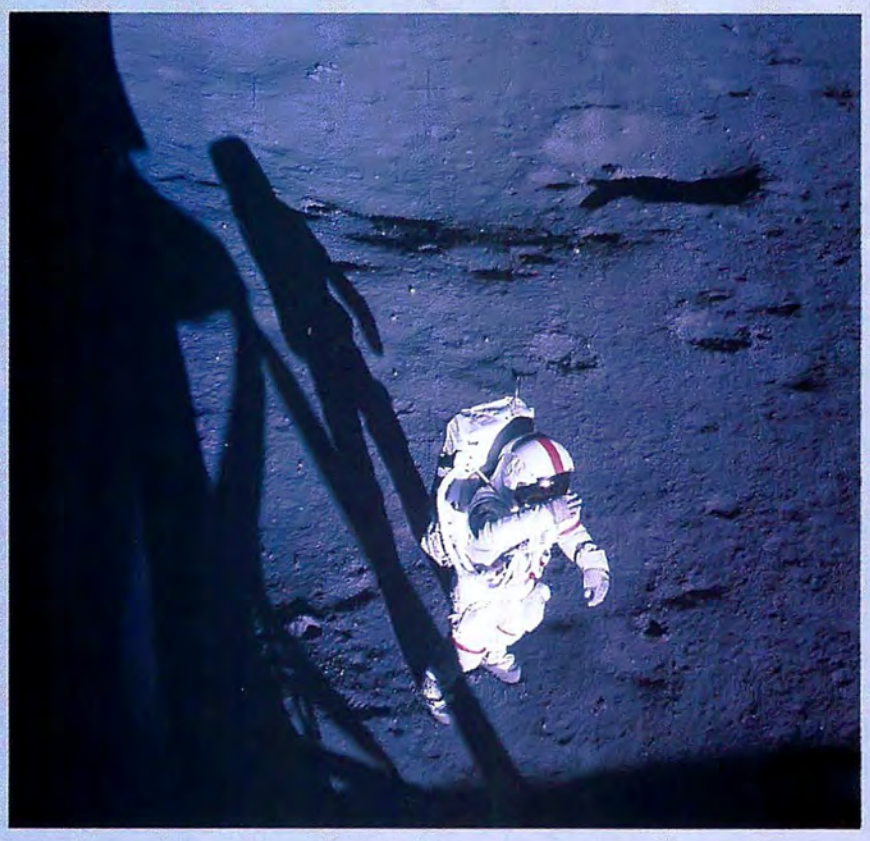
Address _____

City/State/Zip _____

Signature _____
(All orders subject to acceptance)

☐ I prefer not to use a credit card and will pay by check. Enclosed is my deposit of $99.50* for each watch. I will pay the balance as billed in four monthly installments of $49.75 each.

*Connecticut residents add 7½% sales tax. Tennessee residents add 7¾% sales tax.



ON THE MOON

IMAGES OF APOLLO 1969-1972

PUBLISHED BY **FINAL FRONTIER** THE MAGAZINE OF SPACE EXPLORATION

The last 10 miles were on us!

APOLLO 11



On July 20, 1969, NASA's Apollo 11 Lunar Module—the Eagle—landed men on the moon for the first time.

The Eagle was gently lowered to the lunar surface by the TRW-built Lunar Module Descent Engine (LMDE).

Six LMDE's landed modules on the moon. LMDE also thrust the aborted Apollo 13 and its crew into a safe return trajectory.

TRW

TRW Space & Technology Group

©TRW Inc. 1989

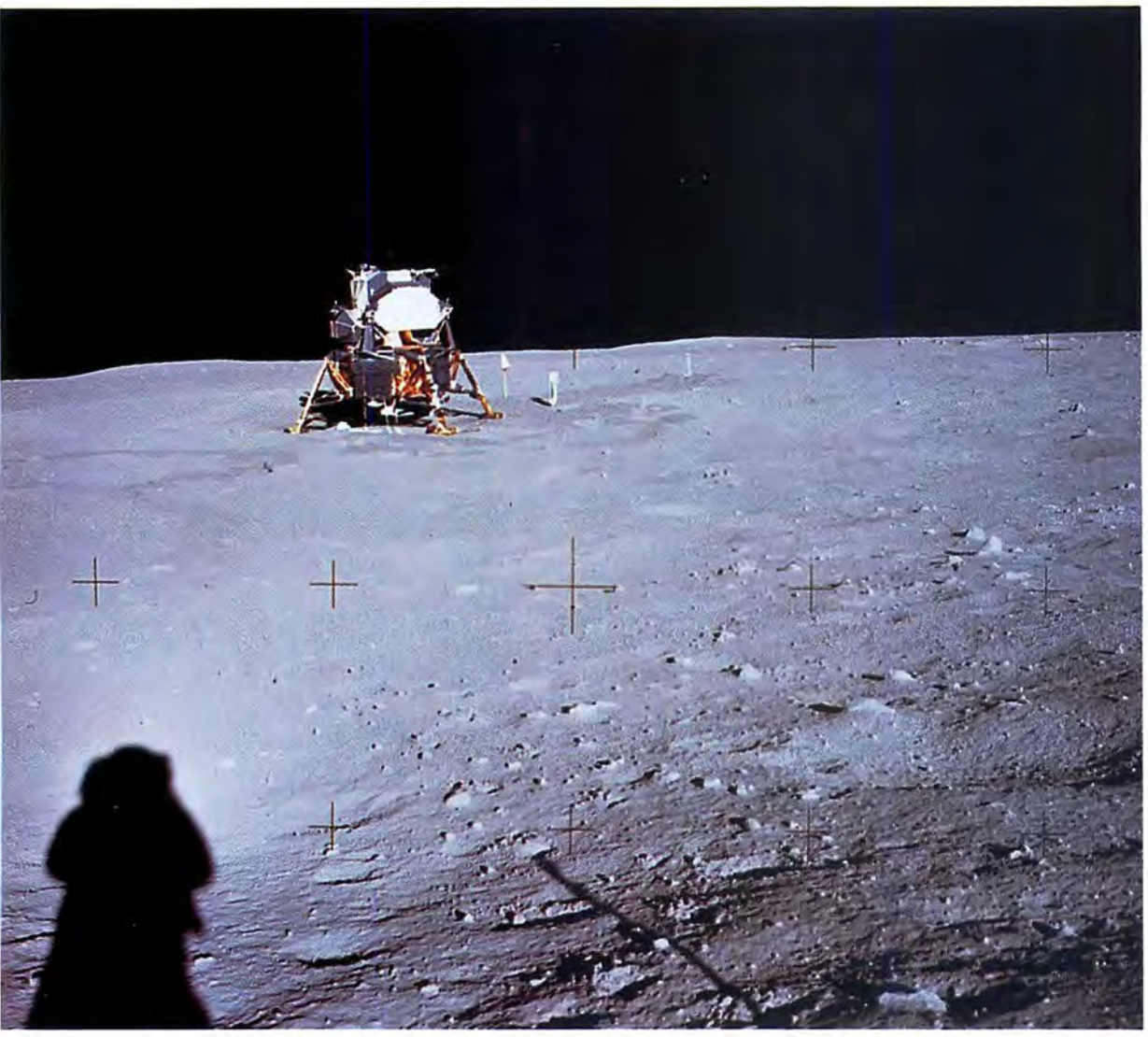
We remember that summer night twenty years ago the way we remember the other cultural earthquakes of the 1960s: the assassination of a president, the arrival of four mop-topped singers from Liverpool, the violence in a faraway place called Vietnam. Like those other events, we experienced it mainly through television. But unlike the others, it still seems, even after twenty years, like a fantasy. We watched a ghostly figure descend on our T.V. screens into an odd jumble of light and darkness. We heard his voice, speaking from such unimaginable distance that his words arrived a long moment after he spoke them. Yet one of the miracles of this midsummer night's dream was that the voice was clear. The figure stood in the shadows, then took a step. There was a pause in the stream of high technology jargon, and we heard a single sentence: "That's one small step for man, one giant leap for mankind." Minutes later, the lone figure was joined by a second, and the two danced in slow motion long into the night, like snowmen brought to life. And the dream was over. ■ Yet it had all been real. Neil Armstrong and Buzz Aldrin actually had done what seemed like science fiction only a decade earlier; they had walked on the Moon. For a moment we were awed; then, as the 60s became the 70s, we lost interest. Other astronauts followed Armstrong and Aldrin to the Moon, their scenes played out on our televisions with ever greater clarity. But by the time the last explorers left the Moon in December 1972, we had stopped watching. ■ Twenty years later, their photographs remain; pictures of men walking on the Moon are as familiar as Warhol's soup cans. We have barely come to terms with the events they record, yet the pictures are as sharp and vivid as ever. Looking at them, we feel the rush of oxygen past our face as we peer out from within a pressurized spacesuit. We hear the soft hum of the machinery that keeps us alive in the vacuum of space. We feel the buoyancy of lunar gravity, and we gaze out at a landscape of stark and alien beauty. And we discover how it really was to be on the Moon.





By Andrew Chaikin



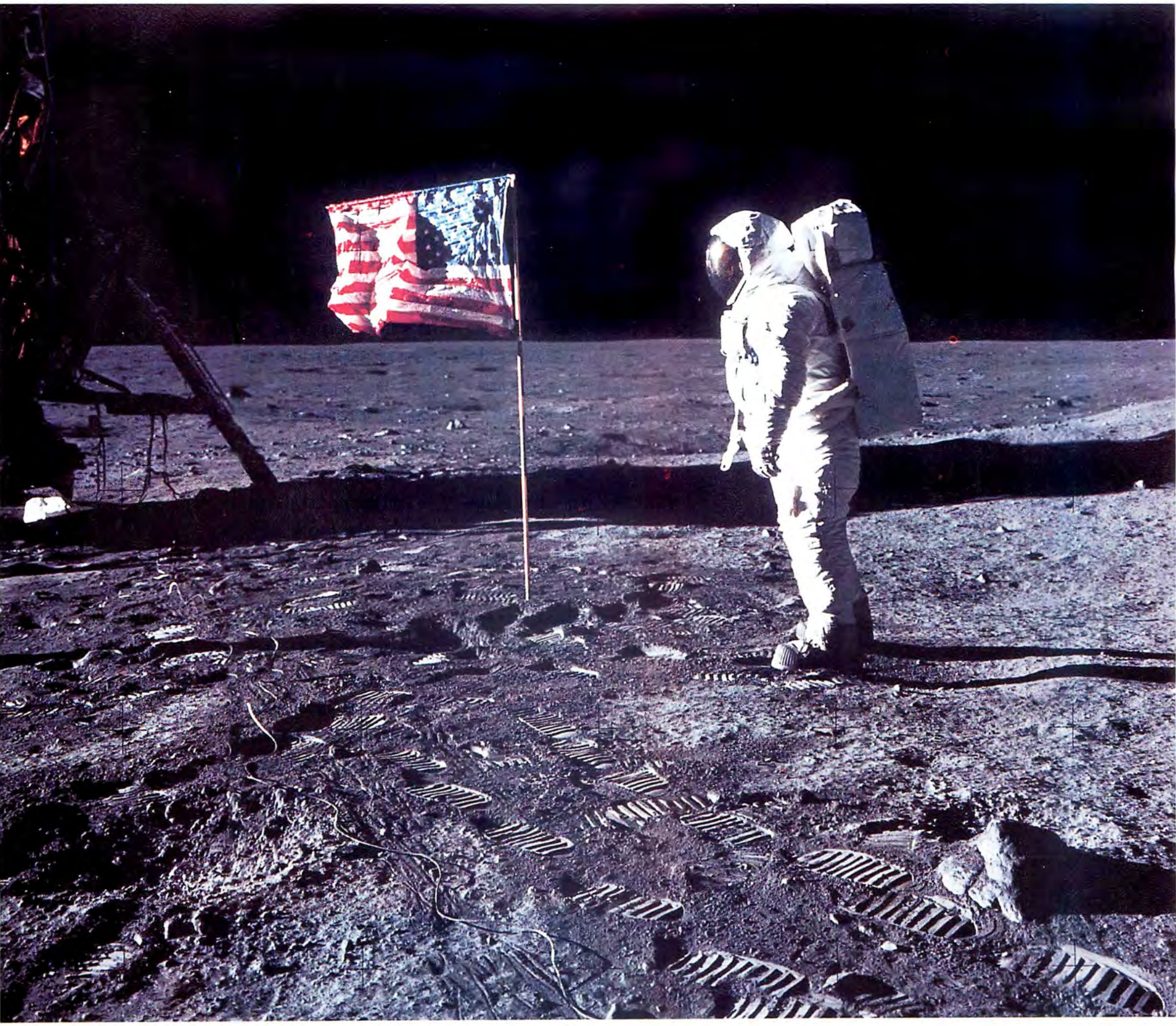


Apollo 11 *Minutes after taking his "one small step," Neil Armstrong snapped the first photo taken by a human being on another world (top). The bag next to the lunar lander contains empty food bags and other items discarded to save weight on the trip home. Armstrong was on his way back from photographing a large crater when he recorded this view of "Tranquility Base" with his own shadow (above). Because he took most of the pictures on the surface, there are almost no clear views of Armstrong on the Moon.*

The flag didn't want to stay up; it almost fell over in the dust while a billion people watched on live television. But with Buzz Aldrin's help, Neil Armstrong finally got it to balance. Then, as Aldrin stood at attention before the wire-stiffened banner, Armstrong backed *away and snapped* this timeless image of a human being planting a flag on another world.

If they had done nothing more than return to Earth with this one photograph, the astronauts would have fulfilled Apollo's mission. But in a brief Moonwalk lasting only two and a half hours, Armstrong and Aldrin also collected rock and soil samples, laid out a collection of scientific experiments and took dozens of stunning photographs of the Sea of Tranquility's stark beauty. The Moon was a place of ancient and untouched magnificence, a museum world preserved nearly unchanged for three billion years.

The landing itself had been hair-raising. An overloaded computer threatened to abort the mission while Armstrong and Aldrin were still thousands of feet above the Moon. In the final minutes of the descent Armstrong was forced to take over manual control to avoid a huge crater strewn with boulders. At last he found a smooth, safe spot about four miles from the planned landing site. With only seconds of fuel left, amid a flurry of dust stirred up by the descent rocket, Armstrong brought *Eagle* down onto the surface so softly that neither he nor Aldrin felt the touchdown. The critical liftoff from the Moon, the rendezvous with Michael Collins in lunar orbit and the trip back to Earth were still to come. But for a moment, as stillness returned to the Moon, the first visitors to another world turned to each other and shook hands without saying a word.



WALKING





Apollo 14 *Map in hand, Ed Mitchell heads for the top of Cone Crater.*

The astronauts who followed Armstrong and Aldrin to the Moon had more on their agenda than just landing and stepping outside. The next two teams of explorers each stayed half again as long as Armstrong and Aldrin had, and took two Moonwalks each, totalling roughly eight hours. The first excursion was limited to setting up an automatic science research station, but the second walk was for exploration. In their quest for the Moon's geologic treasures, these teams of astronauts journeyed on foot up to a mile or more from the safety of their lunar module without fear, putting all confidence in their equipment.

Just moving about on the Moon was a delight. Despite the great bulk of the suits and backpacks—on Earth they would have weighed 350 pounds—the Moon's 1/6-gravity made walking nearly effortless. To Apollo 12's Alan Bean it seemed, during a long run from one crater to another, that his legs would never get tired. Just push off with the toe, soar into space, and land. The astronauts learned to rock from side to side as they ran, creating a new form of locomotion: the lunar lope.

The problem was navigating. On this airless world everything was so unnaturally clear that the astronauts found they had almost no ability to judge distances. And even with photo-maps supplied by the geologists, they had great difficulty recognizing the craters that were their landmarks, hidden as they were in a sea of undulating hills and hummocks. These problems thwarted Alan Shepard and Ed Mitchell of Apollo 14 as they climbed the flanks of Cone crater. They searched for the crater rim until they ran out of time; only after they were back on Earth would they learn that they had missed their objective by only 75 feet.

But Shepard and Mitchell had at least reached the Moon. Their predecessors—James Lovell and his Apollo 13 crew—were almost marooned in space when an explosion crippled their spacecraft 200,000 miles from Earth. Apollo 13 reminded everyone that going to the Moon was, above all, a risky enterprise.



Apollo 14 *First steps: Alan Shepard shades his eyes from the full-strength lunar sunlight.*



Apollo 14 *Explorer in an ancient wilderness: Shepard roams the undulating plains of Fra Mauro.*



Apollo 17 *Gene Cernan at the base of the lunar lander, covered with three days' worth of grime.*



Apollo 17 *The man inside the space suit: Jack Schmitt had raised his reflective, outermost visor for a better view when he was caught by the ground-controlled TV camera during the last of three Moonwalks.*

Apollo 11 *(right) Buzz Aldrin carries experiment packages to be set up on the lunar surface.*

If walking on the Moon was fun, just about everything else was hard work. Dust was a constant impediment. The fine, soft soil—as fine as talcum powder—stuck to everything that touched it. Keeping anything clean—cameras, charts and especially themselves—was a constant struggle. By the end of a long outing, the Moonwalkers looked like chimney sweeps.

The astronauts were constantly fighting the stiffness of their pressurized spacesuits, especially their gloves. Every movement of the hand was like squeezing a hard tennis ball. Tasks that would have been simple on Earth—picking up rocks, twisting sample bags closed—required great effort. Their fingernails, which constantly rubbed against the ends of the gloves, were as sore as if they had been hit with a hammer. By the time they climbed back into the lunar module, the astronauts were nearly exhausted.



But two things distracted them from these hardships: the excitement of being on the Moon and, above all, the relentless pressure of time. No one who went to the Moon felt that he had enough time to do the work on his checklist. Always, there was a voice in his ear—the voice of Mission Control on Earth—calling him to the next task. Near the end of a seven-hour Moonwalk, Dave Scott had to stop and laugh: he had two checklists on his wrists, each telling him to do something different at that very moment.



Apollo 15 *Some of the hardest work on the Moon was spent operating a battery-powered lunar drill. Here Dave Scott labors to make a hole in the ground for a scientific thermometer.*

EXPLORING



Apollo 17 *Lunar rake in hand, Jack Schmitt goes prospecting at the boulder-strewn rim of 2,100-foot Camelot Crater.*



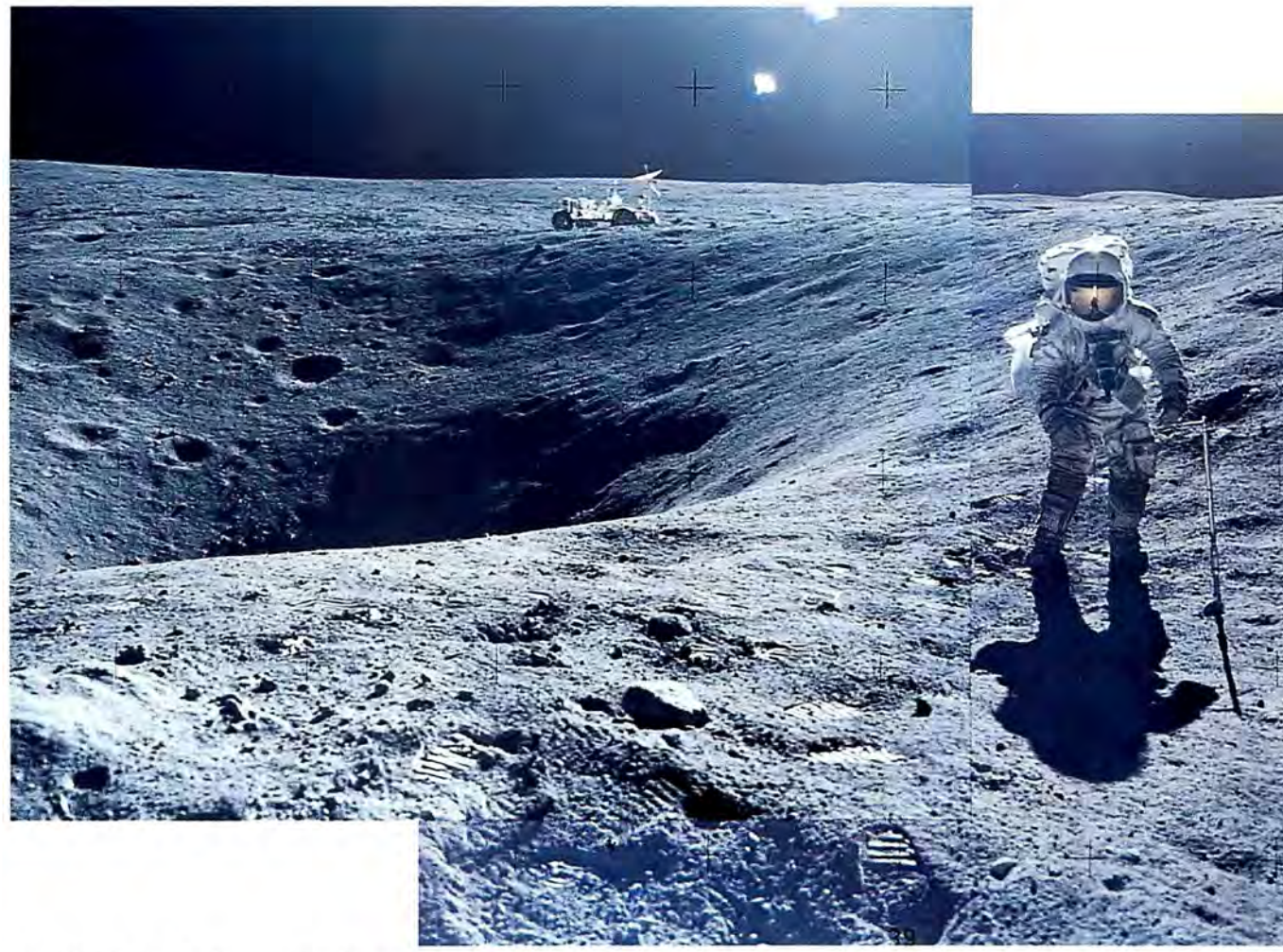
Apollo 15 *High on the slopes of Hadley Delta mountain, Dave Scott takes a picture of a geologic find before picking it up.*

By the time they reached the Moon, the Apollo astronauts were trained lunar field geologists. Each team of explorers strove to do more than the ones before them—travel farther, bring back more rocks, more photographs, more data. Especially on the rover missions, they covered a wide variety of terrain types. To them, the ubiquitous lunar craters were like excavations that had brought precious samples of the lunar crust to the surface.

Before his Apollo 16 landing, John Young had thought about bringing a rope along to help him and Charlie Duke explore the huge North Ray crater, but NASA managers were too nervous about the idea to approve it. When they reached North Ray, Young and Duke stayed well away from the crater rim, knowing that if one of them fell in, he would never be able to climb back out.

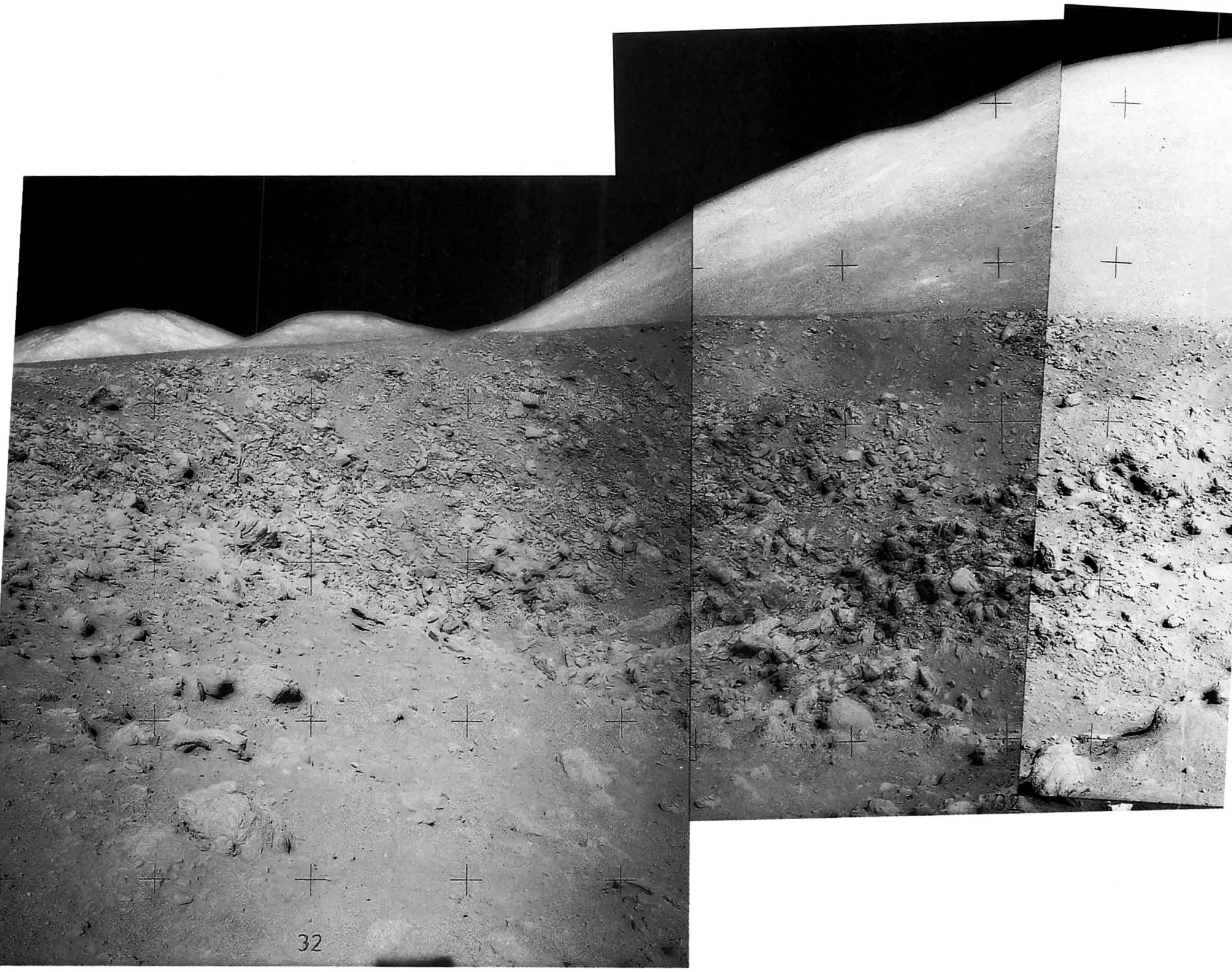
Some of the most spectacular—and exhausting—explorations came on the slopes of the lunar mountains. The rover climbed with such ease that when the astronauts got off to walk they were startled by how steep the mountainside was. Climbing on foot, they soon found, was a tremendous drain of energy. But here were some of the most valuable prizes: samples of the oldest crust of the Moon, nearly as old as the Solar System itself. The view from these high slopes, with the lunar module a tiny dot in the great primordial wilderness, was described by John Young as "one of the most truly beautiful views ever seen by a human being."

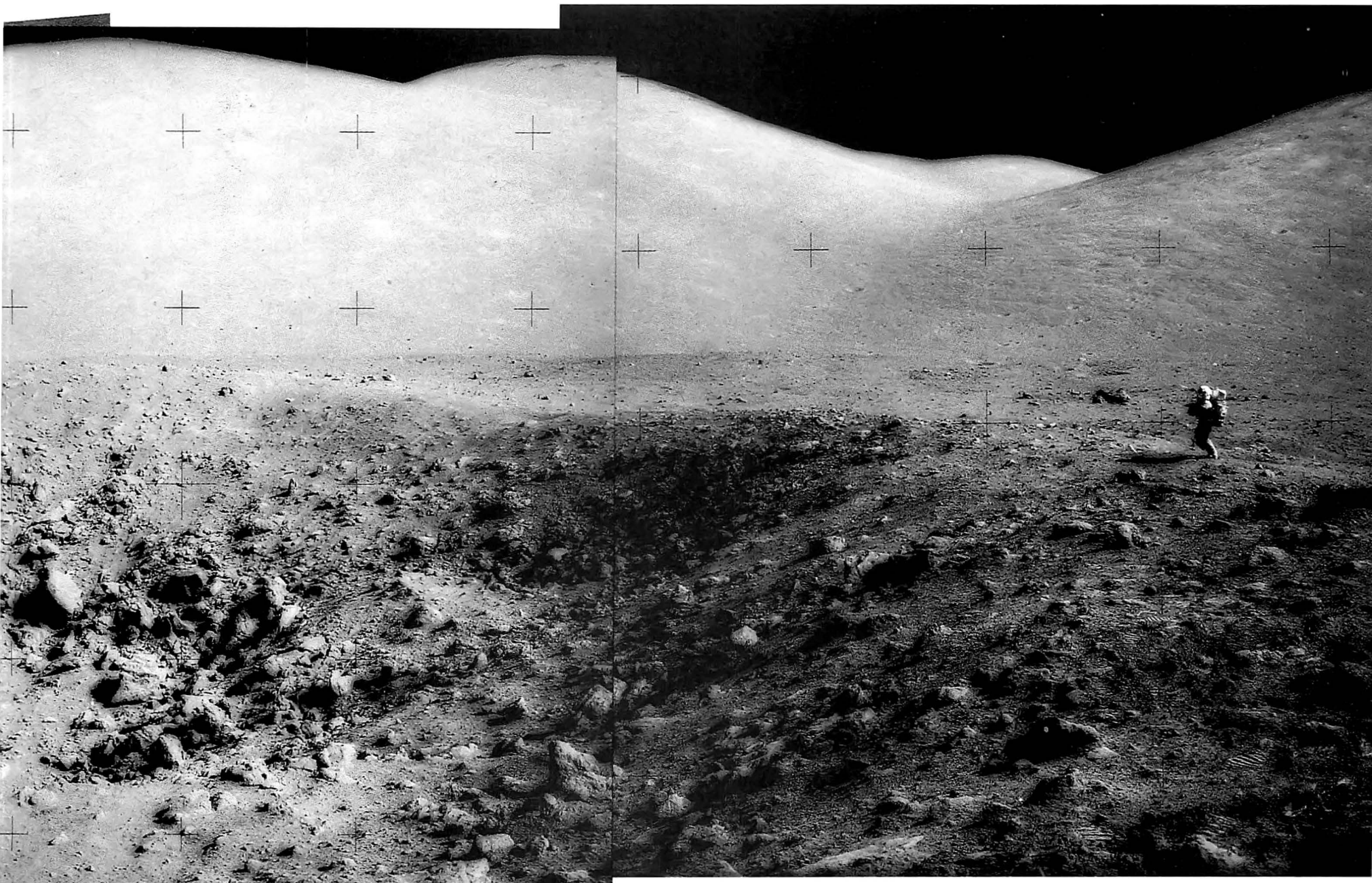
But there was never any time to freelance, to look around and investigate something interesting. Even the moments of awe and personal discovery were fleeting. They would not be experienced fully until after the mission was over, in retrospect, if ever.



Apollo 16 *In a landscape battered by billions of years of meteorite impacts, Charlie Duke poses next to one of the smaller craters he and John Young visited, 100-foot Plum Crater.*

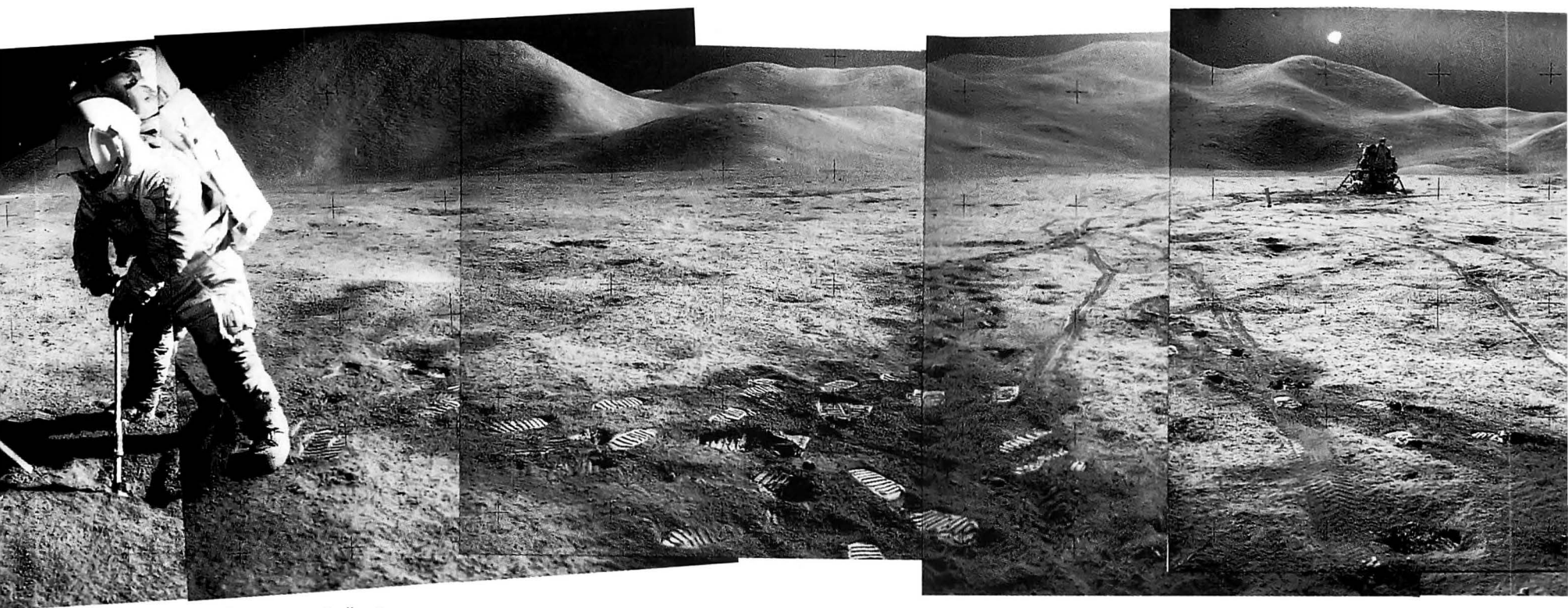
EXPLORING





Apollo 17 *Jack Schmitt pauses to take photographs at the edge of 260-foot Van Serg crater while Gene Cernan records the scene in this series of panoramic photos. In the background, less than two miles away, North Massif rises 6500 feet to dominate the skyline.*

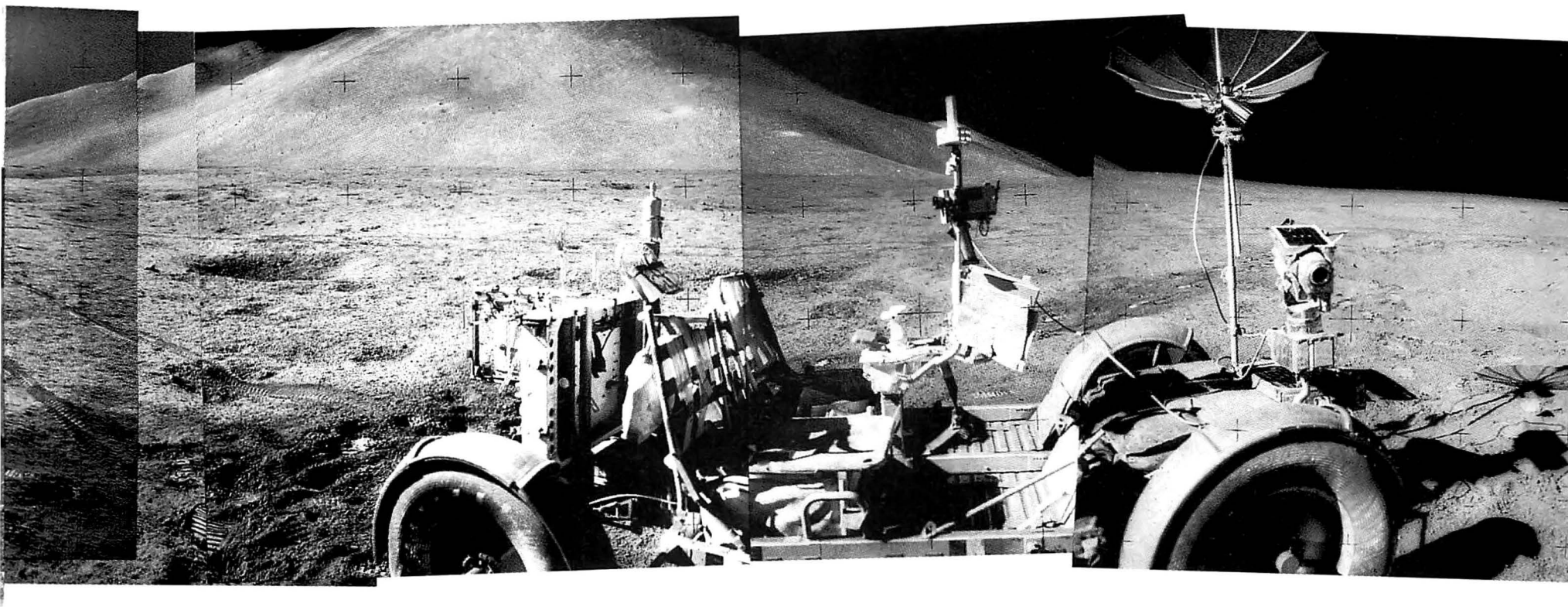
A LUNAR BASE



Apollo 15 *Panorama at Hadley Base.*



Apollo 15 *The lunar lander (background) and rover at Hadley.*



With the final three landings, lunar exploration entered a new phase. The astronauts of the Apollo 15, 16 and 17 expeditions thought of their missions as a different experience from the earlier landings. They wore upgraded backpacks and improved suits, which allowed them to work outside for up to seven hours at a time, nearly a full working day. Driving a battery-powered car called the rover, they could range several miles from their base camp. They had to pace themselves; a good night's sleep, which had eluded earlier crews, was now essential. The later explorers didn't just visit the Moon; they lived there for three days.

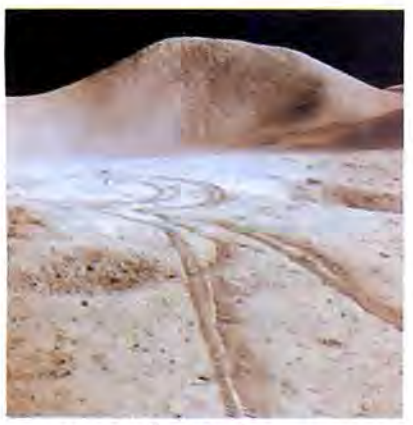
On these extended expeditions, some of the Moon's most spectacular scenery was now within reach. On Apollo 15, Dave Scott and Jim Irwin set down on a broad lava plain at the foot of the Moon's Apennine Mountains. They drove their rover among the craters, to the edge of a winding valley called Hadley Rille, and up the side of Hadley Delta mountain.

In this panorama, photographed by Scott late in the second of three Moonwalks, Irwin is digging a trench to investigate the nature of the lunar soil. In the center, framed by the distant peaks, sits the lunar module *Falcon*. At right is the rover, its tracks criss-crossing the ancient ground.

Even with three days on the lunar surface, the astronauts found they could not accomplish everything they wanted to do. The day after these pictures were taken, Scott and Irwin struggled so long with pulling a stuck lunar drill from the ground that they had to give up one of their most exciting geologic excursions, a visit to a puzzling field of craters called the North Complex. Like all the astronauts, Scott and Irwin left the Moon feeling they had only begun to explore its mysteries.



Apollo 15 *A proud moment: Dave Scott salutes the flag.*



Apollo 15 *Rover tracks.*

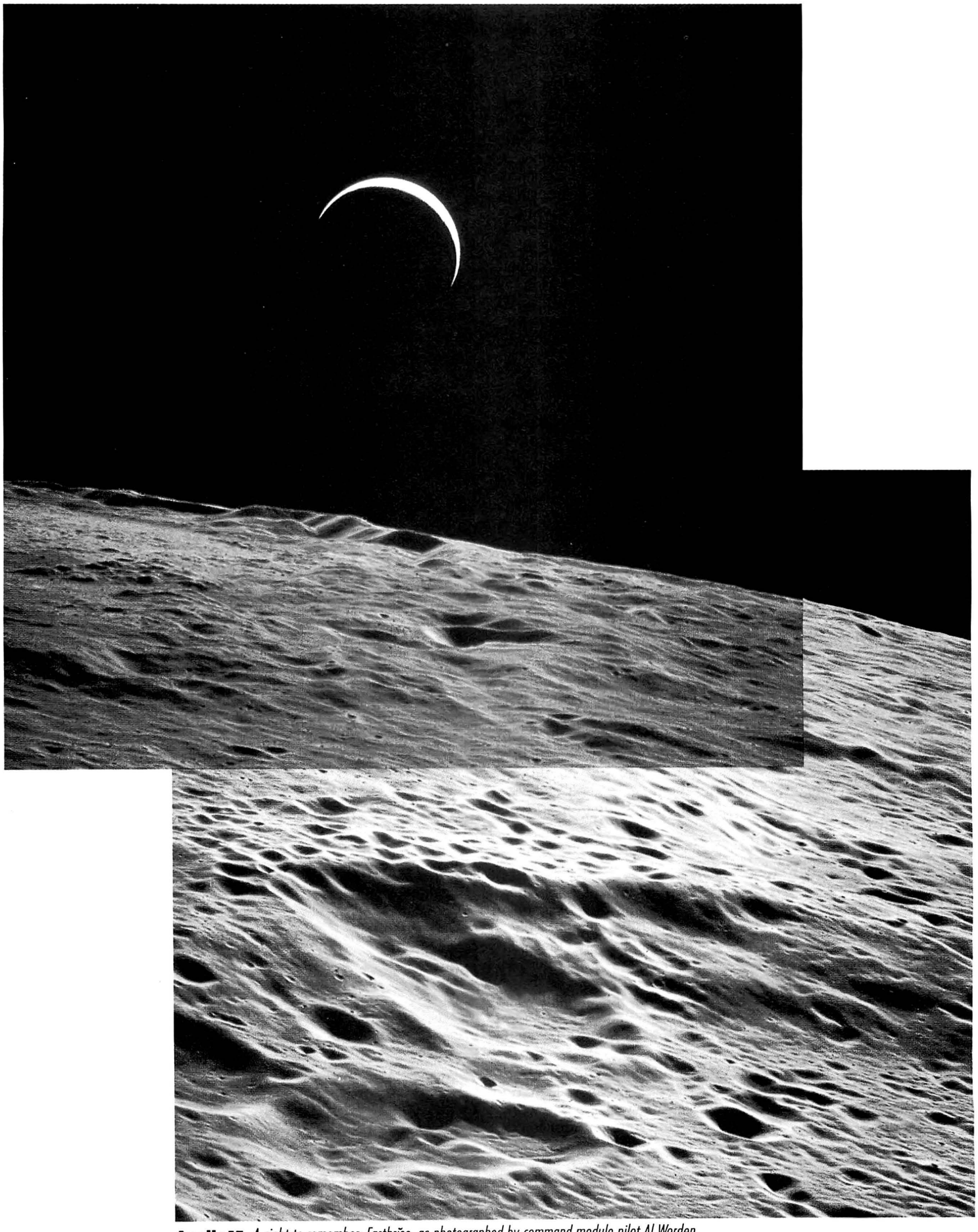
As they go about their lives, the men who went to the Moon rarely look back on Apollo unless someone asks them about it, which happens more often than any of them prefer. But some moments remain vivid in their consciousness: the mixture of pride and humility that came as they stood before the flag, the thrill of geologic discovery, the moments of humor, of surprise, of exhaustion.

Jim Irwin often tells the story of how, at the end of his last Moonwalk, he found himself with nothing to do for the first time in three long days, so he took a five-minute "vacation," running around the lunar module, leaping over craters and feeling like a kid at recess. Sometimes the astronauts think about the things they left behind on the lunar surface—Alan Bean's lapel pin, a snapshot of Charlie Duke's family, a hammer and falcon feather used by Dave Scott to test Galileo's theory of falling bodies, and their footprints, which will remain virtually unaltered for millennia, subject only to the constant rain of micrometeorites from space.

The command module pilots, who orbited the Moon alone while their companions explored the surface, came to know the pockmarked world with an intimacy not afforded the Moonwalkers. Theirs was a global view of lava "seas," enormous craters, ridges, mountains. They knew total isolation in the minutes they spent on the lunar far side, out of radio contact with Earth. None confesses anxiety at this separation from humanity—on the contrary, as fighter pilots, they reveled in their solitude. Like the Moonwalkers, they continually raced the clock, struggling to meet all the objectives on their crowded flight plans. And yet, they came home with their own precious memories: Al Worden still recalls flying in total darkness above the far side, looking out at a universe of unimagined splendor.

But it wasn't the Moon or the stars that the astronauts remember as the most stirring sight of all. Rather, it was the Earth, tiny and precious, rising beyond its battered, lifeless satellite.

The Apollo voyagers will tell you that their photographs don't convey the real experience of going to the Moon. In the coming century, new generations of explorers will have to learn that for themselves.



Apollo 15 *A sight to remember: Earthrise, as photographed by command module pilot Al Worden.*

APOLLO 8

Crew: Frank Borman, James A. Lovell, Jr., William A. Anders
Dates: December 21-27, 1968



The first astronauts to ride the huge Saturn 5 booster, Borman, Lovell and Anders also were the first human beings to leave Earth's orbit. Three days later, on Christmas Eve morning, they arrived at the Moon. After a four-minute blast of their spacecraft's engine they entered lunar orbit, circling the Moon ten times in the next 20 hours, taking photographs, making navigational sightings and beaming live TV transmission back to Earth, including a reading from the Book of Genesis. In the first hours of Christmas Day the astronauts left the Moon to head for a fiery re-entry in the Earth's atmosphere and a pre-dawn splashdown in the Pacific.



Photo by William A. Anders

APOLLO 10

Crew: Thomas P. Stafford, John W. Young, Eugene A. Cernan
Dates: May 18-26, 1969
Command Module: *Charlie Brown*
Lunar Module: *Snoopy*



After Apollo 9's checkout of the lunar lander in Earth orbit, Stafford, Young and Cernan staged a dress rehearsal for the lunar landing. While Young remained in lunar orbit, Stafford and Cernan descended in *Snoopy* to within 50,000 feet of the Moon's surface, testing the lander's engines and reconnoitering the landing site chosen for Apollo 11. An anxious moment came when Snoopy's ascent stage gyrated wildly minutes before a scheduled engine firing, but Stafford stabilized the craft and the pair went on to rendezvous with Young. For those watching on Earth, Apollo 10 offered another first: live color television transmission from space.

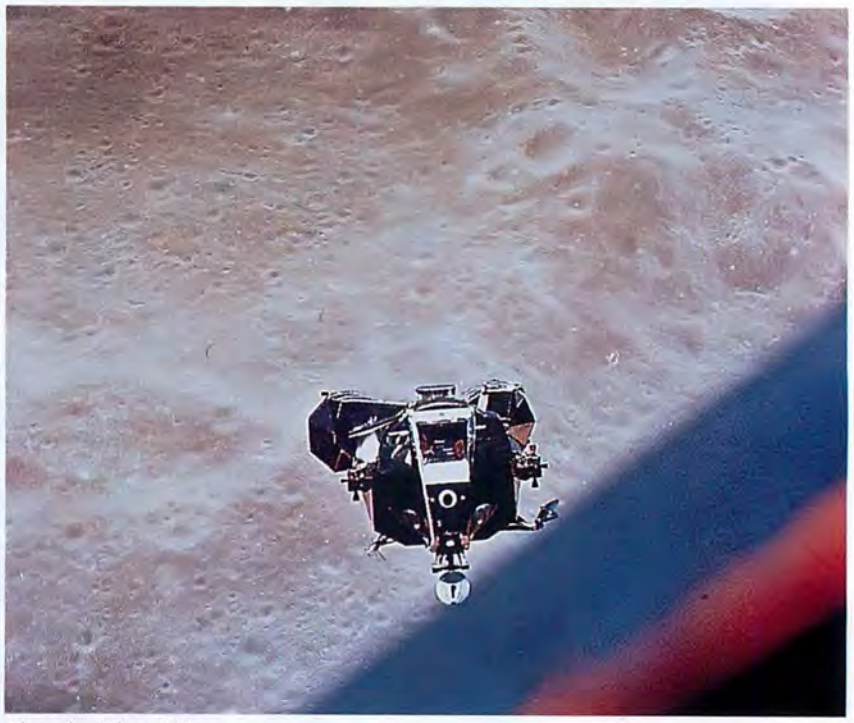


Photo by John W. Young

APOLLO 11

Crew: Neil A. Armstrong, Michael Collins, Edwin E. Aldrin, Jr.
Dates: July 16-24, 1969
Command Module: *Columbia*
Lunar Module: *Eagle*



Apollo's culmination, the result of eight years of planning and test flights, came on July 20 at 4:17 p.m., Eastern Daylight Time, when Armstrong and Aldrin touched down on the Moon's Sea of Tranquility while Collins remained in *Columbia*. More than six hours later, wearing pressurized space suits, Armstrong and Aldrin climbed out of Eagle and spent two and a half hours walking and working on the surface. After a sleepless night inside the lander (the cabin was too bright and too chilly), the men fired *Eagle*'s ascent stage engine to lift off the Moon, 21 hours after they had touched down, and rejoined Collins. The three astronauts returned to Earth with 46 pounds of lunar rocks and soil.

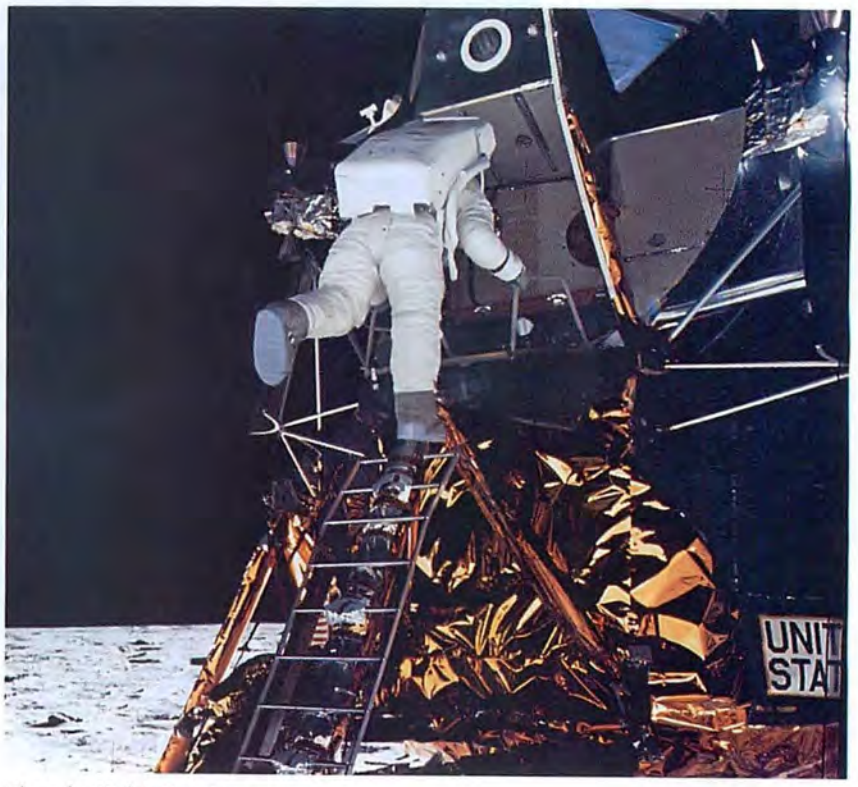


Photo by Neil A. Armstrong



Throughout the thirty-year history of the NASA manned space program, AiResearch has supported the lives of a generation of space explorers.

We drew our first breaths aboard the Mercury flights. We were there when the whole world held its breath during America's first EVA, a spacewalk from a Gemini capsule. We watched over Apollo's one great step for mankind. And for six months, we orbited with Skylab, providing an atmosphere conducive to scientific research.

Today, working with several of America's most prestigious aerospace contractors, we're expanding our broad technological base. With several systems aboard the space station.

Supporting this growth in technology is the Allied-Signal Engineered Materials Research Center. Here we explore materials and techniques not available elsewhere. Technology that will eventually take life support beyond earth orbit.

Make our world-class facilities and other space experience part of your next project. After all, no one should work in a vacuum.

AiResearch Los Angeles Division, 2525 West 190th Street, Torrance, CA 90509. (213) 512-5488.

Allied-Signal Aerospace Company

Allied Signal

APOLLO 12

Crew: Charles Conrad, Jr., Richard F. Gordon, Jr., Alan L. Bean
Dates: November 14-24, 1969
Command Module: *Yankee Clipper*
Lunar Module: *Intrepid*



Because Armstrong and Aldrin had missed their target point by some four miles, Apollo 12's goal was to land at a pre-chosen spot on the Moon. Conrad and Bean set down on the Ocean of Storms roughly 600 feet from the automated Surveyor 3 probe, which had landed on the Moon in April 1967. In their two Moonwalks, which totaled more than seven hours, Conrad and Bean set out a station of scientific experiments, collected samples and visited the Surveyor, parts of which they snipped off to return to Earth for analysis. During his 31 hours alone in lunar orbit, Gordon photographed the Moon and sighted lunar landmarks.

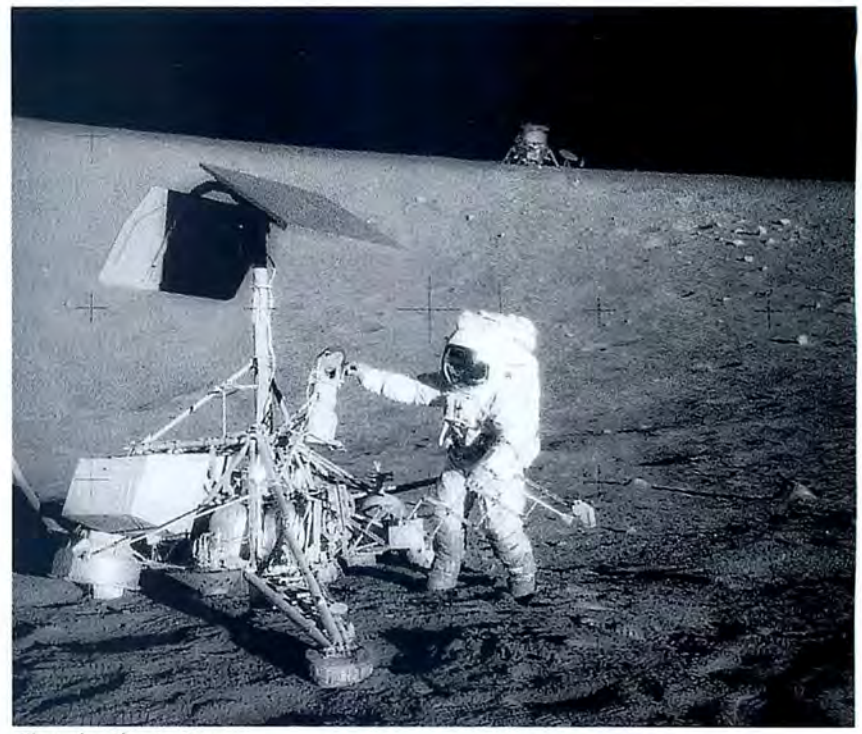


Photo by Alan L. Bean

APOLLO 13

Crew: James A. Lovell, Jr., John L. Swigert, Fred W. Haise, Jr.
Dates: April 11-17, 1970
Command Module: *Odyssey*
Lunar Module: *Aquarius*



After an oxygen tank exploded 200,000 miles outbound from Earth, Lovell, Swigert and Haise aborted their mission and faced a grueling four-day trip home. After using *Aquarius'* engine to put them on a return course, the astronauts looped around the Moon and headed Earthward. With their command module completely deactivated, the men spent the journey crowded into the tiny cabin of the lunar module. With electrical power and cooling water at a premium, the astronauts turned off nearly every system. The lunar module's cabin chilled to 40 degrees, while parts of *Odyssey* were near freezing. On Earth, mission controllers worked feverishly to plan the rocket firings and other crucial maneuvers that brought the astronauts home safely.



Photo by John L. Swigert

APOLLO 14

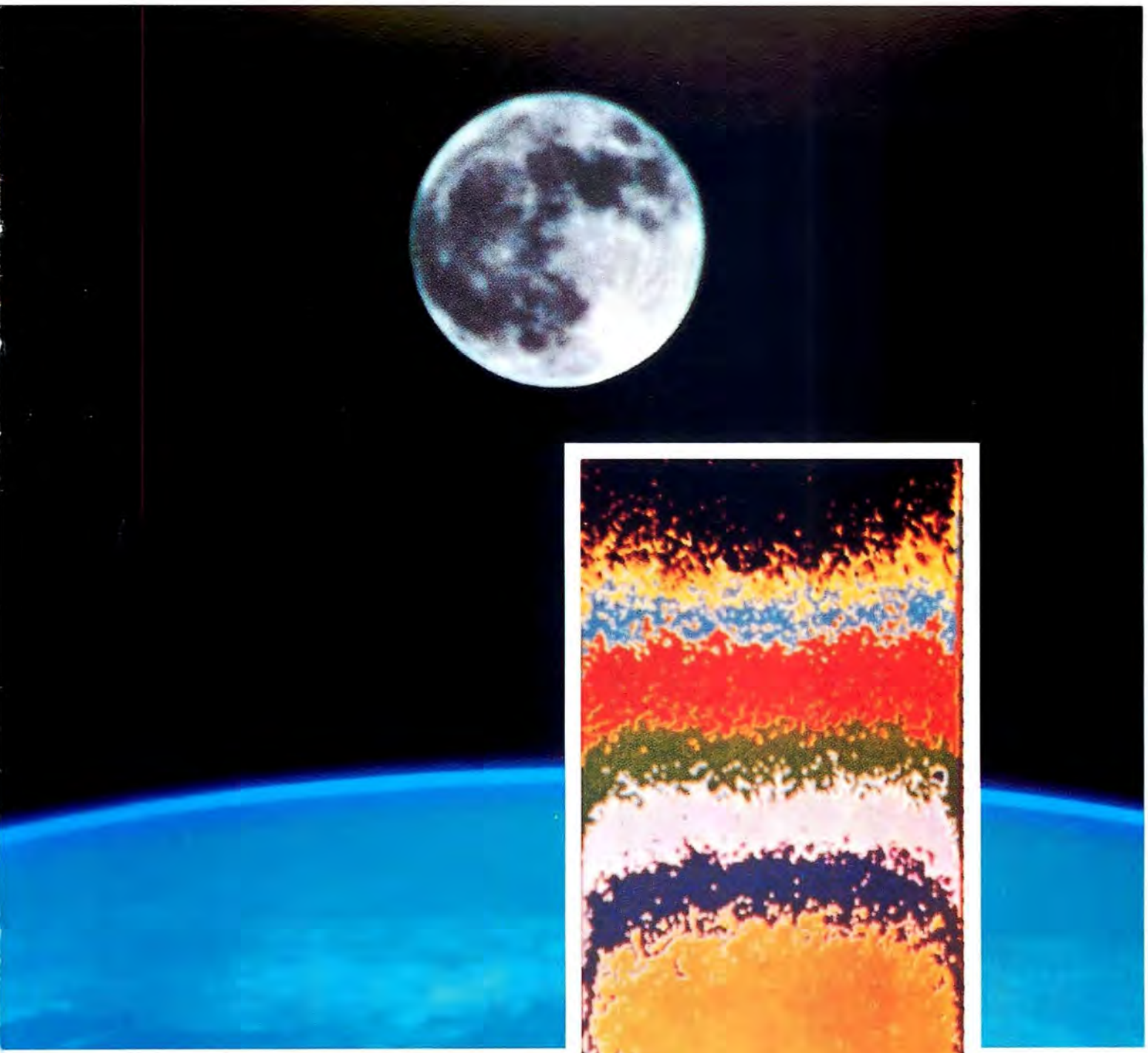
Crew: Alan B. Shepard, Jr., Stuart A. Roosa, Edgar D. Mitchell
Dates: January 31-February 9, 1971
Command Module: *Kitty Hawk*
Lunar Module: *Antares*



Shepard, Roosa and Mitchell carried the torch for Apollo 13, fulfilling the mission that was denied the previous crew. Shepard and Mitchell spent more than nine hours exploring the Moon's Fra Mauro region during two Moonwalks. Their gear included a two-wheeled tool cart, which they pulled like a rickshaw. Despite an unsuccessful attempt to reach the rim of Cone Crater, the men accomplished the mission objectives, returning to Earth with samples older than any found on the first two landings.



Photo by Alan B. Shepard



Metals made in space.

Wyle technology is lending a hand.

The new era of manufacturing in space.

Metals, crystals, proteins. All manufactured better in space, because of the weightless environment.

It will revolutionize our lives. And it's beginning now. Stronger metal alloys. More effective drugs. Purer optical materials.

Wyle technology is lending a hand. Our systems engineering technology is putting manufacturing devices in space. And our processing technology is producing new materials in space.

At Wyle Laboratories, we have over 1,000 scientists, engineers and technicians at specialized facilities throughout the United States. They're working with NASA, leading universities and private business. They're helping bring about the new era of manufacturing in space.

WYLE LABORATORIES 40 years

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP

7800 Governors Drive, Huntsville, AL 35807
(205) 837-4411

APOLLO 15

Crew: David R. Scott, Alfred M. Worden, James B. Irwin
Dates: July 26-August 7, 1971
Command Module: *Endeavour*
Lunar Module: *Falcon*



Apollo 15 was the first of the extended lunar exploration missions. Scott and Irwin lived on the Moon for three days, and in three Moonwalks totalling 19 hours, they drove their lunar rover more than 17 miles and collected 169 pounds of rocks. The most celebrated find was a small white chunk of the ancient lunar highlands, which became known as the "Genesis Rock." Live television from a camera mounted on the rover conveyed the events on the surface with unprecedented clarity. Meanwhile, in lunar orbit, Worden carried on his own mission of exploration, training a battery of cameras and sensors on the Moon below. During the trip back to Earth, Worden took a spacewalk to retrieve film from the side of the spacecraft.

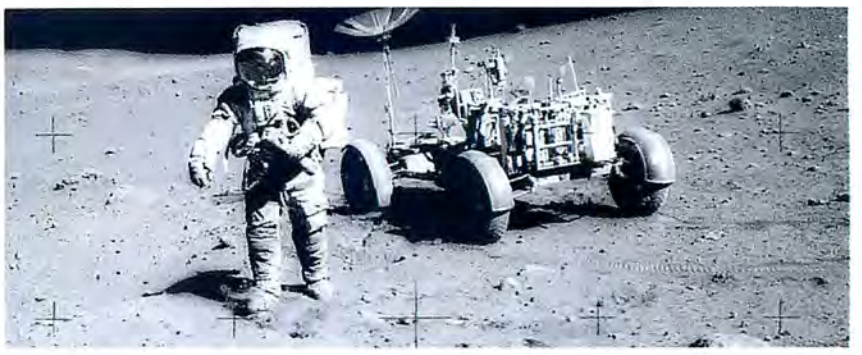


Photo by James B. Irwin

APOLLO 16

Crew: John W. Young, Thomas K. Mattingly II, Charles M. Duke, Jr.
Dates: April 16-27, 1972
Command Module: *Casper*
Lunar Module: *Orion*



A problem with the Command Module rocket engine almost forced the astronauts to call off the landing, but after a six-hour cliffhanger, while mission controllers analyzed data, Young and Duke were given the go to land. While Mattingly orbited the Moon solo for three days, Young and Duke explored the Descartes highlands. Their rover excursions included a drive up the side of Stone Mountain, a venture to the lip of huge North Ray crater, and a confrontation with a 40-foot high boulder they called "House Rock."

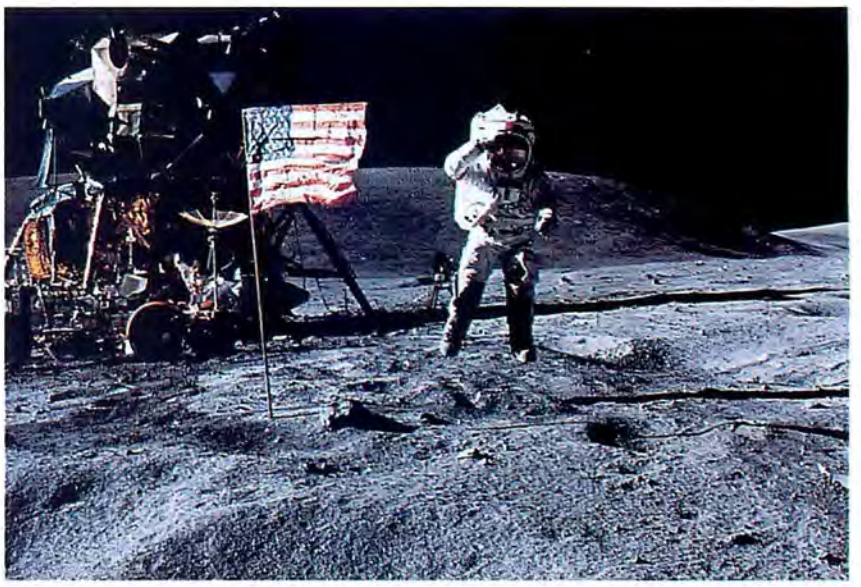


Photo by Charles M. Duke Jr.

APOLLO 17

Crew: Eugene A. Cernan, Ronald E. Evans, Harrison H. Schmitt
Dates: December 7-19, 1972
Command Module: *America*
Lunar Module: *Challenger*



On the final Apollo expedition, Cernan and Schmitt took three Moonwalks in the Moon's Taurus-Littrow valley for a total of 22 hours—more time than Armstrong and Aldrin had spent on the lunar surface altogether. Apollo 17 was a spectacular finish to the program: 75 hours on the Moon, 242 pounds of samples, thousands of photographs from the surface and lunar orbit. Among the most notable finds were a deposit of orange soil discovered by Schmitt, the only professional scientist to visit the Moon.

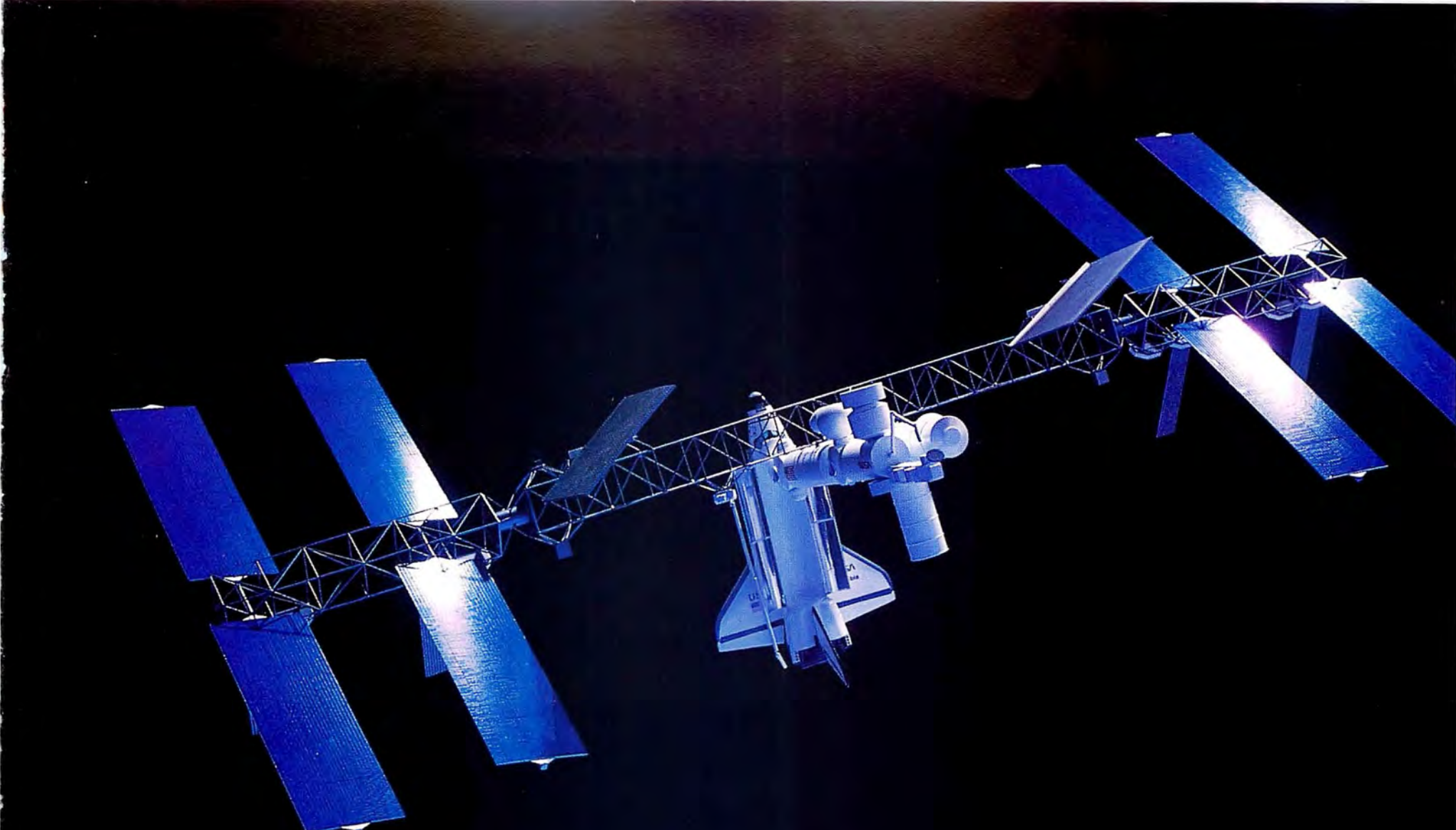


Photo by Eugene A. Cernan

Andrew Chaikin is writing the story of the men who went to the Moon and their experiences, forthcoming from Viking Press.

All photos courtesy NASA. Television image (bottom of page 6) courtesy Greg Linebaugh.

PUBLISHED BY
FINAL FRONTIER
THE MAGAZINE OF SPACE EXPLORATION
2400 Foshay Tower
Minneapolis, MN 55402 U.S.A.



"Knowledge Engine"

Stimulant to industrial genius, way-point to the galaxies,
classroom for science, but most of all,
a gift of vision from this generation to its children.

Freedom Space Station

MCDONNELL DOUGLAS

SETTING THE CLOCK BACK FOURTEEN BILLION YEARS.

Imagine capturing the image of the universe shortly after its creation. The momentous launch of the Hubble Space Telescope will open a window into space that will allow us to see the cosmos as never before.

The Space Telescope is capable of seeing 14 billion light-years into the past. The images we receive will be those of the universe as an infant, which may hold the key to the creation and ultimate fate of the cosmos. But the Space Telescope will function as much more than a cosmic time machine.

The Space Telescope will reveal unimagined secrets of the universe, providing answers to hundreds of questions, but undoubtedly posing thousands more.

The Hubble Space Telescope represents one of Lockheed's greatest achievements in systems integration. The monumental task of coordinating this international effort has given humanity a tool to expand the cosmos. From the first Agena rocket launch, to the first steps on the moon, to the new Advanced Solid Rocket Motors for the Space Shuttle, Lockheed has been an integral part of NASA's accomplishments. And as the most broadly based contractor of the Space Station Freedom, Lockheed is keeping the clock running into the next century of space exploration.

Lockheed
Missiles & Space Company
Giving shape to imagination.

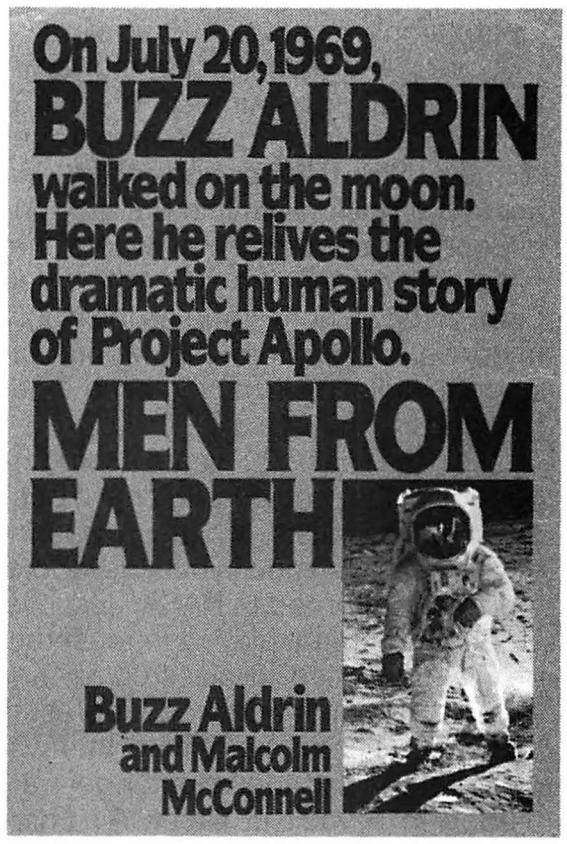
Art Courtesy of NASA.



REVIEWS

Men From Earth
By Buzz Aldrin and Malcolm McConnell
Bantam Books
336 pages. $19.95

By Thomas O'Toole



Neil Armstrong still hasn't written a book about being the first man to walk on the Moon, but his Apollo 11 co-pilots have almost made up for their commander's silence. Mike Collins wrote *Carrying the Fire* and *Liftoff,* easily the best accounts authored by an astronaut. Now Edwin (Buzz) Aldrin has written his own second book.

You won't confuse *Men From Earth* with its predecessor, *Return To Earth,* penned in 1973 and panned by critics immediately thereafter. Aldrin's second book is a solid and rewarding description of the astronaut experience, and an exciting recreation of the dramatic struggle between the United States and the Soviet Union to see who would be first to land humans on the Moon.

Aldrin starts out by describing America's astronaut corps in offhanded fashion. The Original Seven, he tells us, was an Original Six until Bob Gilruth, the director of the Manned Spaceflight Center, said NASA would have to have seven because nobody could agree on the sixth Mercury astronaut. Wally Schirra "tended to treat everything and everybody as if life were one big joke." Alan Shepard? "He had a knack for making friends with influential people," writes West Pointer Aldrin. "I suppose he was the kind of officer my dad had in mind when he wanted me to attend the Naval Academy."

Aldrin points out that test pilot Chuck Yeager couldn't apply because he didn't have a university degree: "The white scarf, stick-and-rudder jockey who could hop into the cockpit of anything with wings and 'ring the sumbitch out' over the Mojave Desert didn't really belong in the astronaut corps."

He's no diplomat, but Aldrin tells it like he thinks it is. "There's no doubt the original seven (no longer uppercased) and all of my colleagues in the astronaut corps were patriotic," Aldrin says, explaining why the astronauts wanted to beat each other into space and onto the Moon, "but every pilot worth his salt wanted more than anything to fly higher and faster than his peers. Some lucky bastard was going to do it, and all of us, from the original seven through the later groups, weren't going to just sit back and let somebody else have all the fun."

Aldrin goes into excruciating detail about the American-Russian race to the Moon, giving painstaking attention to little-known pieces of history. Yuri Gagarin got to be the first man in space, he writes, because he was a proletarian's son, was Russian on both sides of his family back for three generations, and was "short enough to fit through an enlarged ejection hatch" on the Soviet spacecraft.

The former astronaut is at his nasty best when criticizing his own colleagues. On Jim McDivitt: His "awkward attempts at an eyeball rendezvous (on his Gemini flight) were an utter failure.... McDivitt had never grasped much rendezvous theory during his Houston training." Naturally, Aldrin's candor got him into trouble, like the time he told Frank Borman how to cut down on wasted time during Borman's upcoming Apollo 8 flight. "Goddamn it, Aldrin," Borman snapped, "You got a reputation for trying to screw up guys' missions. Well, you're not going to screw up mine."

The second human to walk the lunar surface also is in top form when he gets around to explaining how he was picked for Apollo 11. Honest as always, Aldrin writes how hard it was to accept that Armstrong was the first person on the Moon. The lunar module pilot maintains that it was in the script for *him*—not the mission commander—to be the first out, but that plans were changed to put the civilian (Armstrong) out first. After all, the Vietnam War was on and the world was turning against America's involvement.

To his credit, Aldrin turns his back on all that to describe the two astronauts, side by side, descending to the Moon in Eagle, their landing craft. "Neil nodded, his tired eyes warm with anticipation. I was grinning like a kid. We were going to land on the Moon." □

Now a Washington freelance writer and national editor of AmericaWeek electronic newsmagazine, Thomas O'Toole covered the Apollo program as space correspondent for the Washington Post.

Several of the astronauts who went to the Moon have written first-hand accounts of the experience:

Armstrong, Aldrin and Collins (with *Life* magazine's Gene Farmer and Dora Jane Hamblin): *First on the Moon,* Little, Brown, 1970.

Borman, Frank (with Robert J. Serling): *Countdown, An Autobiography,* Silver Arrow, 1988.

Collins, Michael: *Carrying the Fire: An Astronaut's Journeys,* Farrar, Straus, 1974; *Liftoff,* Grove Press, 1988.

Irwin, James (with William A. Emerson, Jr.): *To Rule the Night,* A.J. Holman, 1973.

Worden, Alfred M.: *Hello Earth: Greetings from Endeavor,* Nash, 1974. (A collection of poems by the Apollo 15 command module pilot.)

Where Have All the

Scientists, museum-goers—even witch doctors—are still romancing the stones.

BY BETH DICKEY

Inside a colorless, aseptic, echoing vault at the Johnson Space Center in Houston is NASA's treasure chest. Here, behind a foot-thick door, the space agency hoards the riches that American astronauts brought home from the Moon two decades ago, only occasionally releasing a sample or two for some deserving researcher to use or abuse.

There are motion detectors in the ceilings and double combination locks on all the doors, and you can't get past them without John Dietrich, NASA's curator of the lunar samples, at your side. In the two months before my visit, Dietrich had admitted only a dozen people. The select, along with the precise times and exact reasons for their comings and goings, are listed in a loose-leaf notebook left open on a cold metal bench in the laboratory dressing room. There was a scientist seeking lunar samples. A Japanese television crew. Nine security guards. Now me.

Some taxpayers might complain that we didn't get our $25 billion worth from the Apollo program, but not the researchers who've spent the past 20 years examining the 842 pounds of lunar rocks, pebbles and sand returned by six different expeditions. And not the officials of the National Aeronautics and Space Administration, who guard the Apollo booty as if it were the gold in Fort Knox.

Three of the biggest gems are displayed in a window where curious tourists can watch the samples being apportioned. Inside a cavern of glass and stainless steel, technicians in white smocks, boots, gloves and hats fill the orders for lunar sample allocations. Virtually every move, every saw cut they make, is photographed and documented. Pebble by pebble and grain by grain, they surrender pieces of an alien world to Earth-bound explorers.

"Those are the only samples we have, and we don't know if we'll ever get any more," says Graham Ryder, a member of the independent Lunar and Planetary Sample Team, a committee of experts that reviews requests for lunar samples.

To keep the Moon rocks from disintegrating in Earth's atmosphere, NASA stores them in a gaseous nitrogen vacuum. Almost 615 pounds of material are in the pristine vault in Building 31A at Johnson Space Center, where they have never been exposed to oxygen. Eight of the 50 core samples the Apollo astronauts took from the Moon with special drills have never even been touched.

Over the past 20 years, some 16 pounds of the precious stuff have been given to scientists, while 59 pounds have been examined in outside laboratories and returned to NASA. Just over 21 pounds are displayed in museums or are circulating in classrooms, and about 118 pounds—rare and representative samples of everything that was collected on six Apollo landings—are hidden in a vault at Brook Air Force Base in San Antonio, Texas.

Another 17 pounds, give or take, have simply disappeared over the years. In the early days, some samples may have been misplaced in the laboratory or dropped into wastebaskets by clumsy handlers. Some material either couldn't be recovered from an experiment or was turned to dust under the modified meat saw technicians use to slice the larger samples. Some material has been lost, and some stolen. A burglary and a van theft claimed two trophy samples a couple of years ago.

Dietrich escorts me into the prep room, where Andrea Mosrie, a senior scientist with the lab's contractor, Lockheed Electronics and Space Company, is waiting with a smock, gloves and hood to cover my hair and boots. She instructs me to cover my shoes with the boots before I step off the doormat onto the tiled floor. While I don the bunny suit, Dietrich replaces his wire-framed glasses with plastic ones; he and Mosrie decide that since I can't see without my glasses, it's okay to let gold-plated rims in just this once.

The purpose of the garb and the glasses is to keep microscopic flecks of dust—metal, skin and lint, for example—from getting inside the laboratory and settling on the lunar material. Even the slightest contamination could render a sample useless for experimentation.

The Moon has essentially the same chemical elements as Earth, but in different proportions. There's more lead, for example, in a droplet of solder than there is in all the lunar samples put together. Scientists determine the age of the samples by measuring their lead content. Likewise with gold—a tiny fleck from a wedding ring or an electronic component could increase the gold concentration in a sample so much that it would be impossible to determine its origin.

The three of us step into an airlock, a blustery closet with doors on both sides, which sucks the dust and dirt off our bodies as it exchanges stale air for fresh. After a minute in the air chamber,



Moon Rocks Gone?

Dietrich opens the door and we step inside his laboratory.

I had expected it to smell like Spic-n-Span. "Everybody says that," Mosrie acknowledges. "But you don't smell anything. Just clean air." Which, of course, is the point.

We watch a handful of technicians quietly filling curatorial orders. They manipulate the samples by sticking their arms into long black rubber gloves that protrude into the nitrogen-filled cases. If I didn't know better, I would guess that Lockheed geologist Kim Willis was moving parking lot gravel back and forth between muffin tins. Actually, she's weighing, measuring and separating particles of an Apollo 16 black-and-white breccia—a rock formed in the heat of a meteorite impact—for a "customer," Odette James of the United States Geological Service.

"If the order says to get 20 particles from this one specific sample, getting as many of the representative lithologies within the samples, it's my job to do that," Willis explains. "I have to make sure all the weights add up. We can't lose large numbers of samples, because it's not like we're going back tomorrow to get some more."

James, a mineralogist, has studied lunar samples since the Apollo days. She is one of an elite group of scientists at some 40 laboratories in the United States and about 15 overseas whose proposals for examining the lunar samples have been good enough to pass the Lunar and Planetary Sample Team's muster.

Graham Ryder, an expert on the Apollo 15 basalt samples, laments that so few scientists have been creative and patient enough to get their hands on a piece of the Moon. "People think that all the important work was done in the first five years, and that all the answers we have about [the Moon] are set in stone," he contends.

As a matter of fact, the lunar samples have prompted more questions than they have answered. Scientists thought the samples would settle arguments about the Moon's origin. Before the Apollo missions, there were three contending theories: that the Moon formed near Earth as a distinct body; that it was a piece of Earth; or that it formed somewhere else in the Solar System and was captured by Earth's gravity.

The samples dashed the theory that the Moon separated from Earth, but in the past five years, a fourth theory has been proposed: that the Moon is a chunk of debris resulting from a collision between a young Earth and another planet about the size of Mars.

Today, many of the samples doled out by NASA are used in experiments to learn about construction materials for a future Moon base. It took T.D. Lin, the principal research engineer at Construction Technology Laboratories in Illinois, two years to convince the Lunar and Planetary Sample Team that he could turn Moon dirt into building blocks. Three years ago, Lin used soil collected by the Apollo 16 astronauts to make a one-inch cube of concrete, which supports his theory that sturdy buildings can be built from materials found on the Moon.

Lin's first request for 320 grams (to make a standard two-inch test cube) apparently was too much for the committee to swallow. The 40 grams he eventually received was still worth about $280,000, based on the cost of the Apollo program and the amount of material the Moonwalkers brought back. So NASA ordered Lin's company to put a round-the-clock guard on the room where the sample was kept during the three months the company needed to manufacture the world's most expensive concrete block.

Every research proposal is considered, says Ryder, but there have been some "weird ones" among the rejects.

For instance, there was the guy who collected dirt from around the world, who wanted some Moon soil to add to his private collection. "It doesn't hurt to ask, but it wastes everybody's time," Ryder says. Then there was the witch doctor in India who wanted to dissolve bits of the Moon in milk, claiming that it would cure chronic ills determined (supposedly) by the lunar cycles.

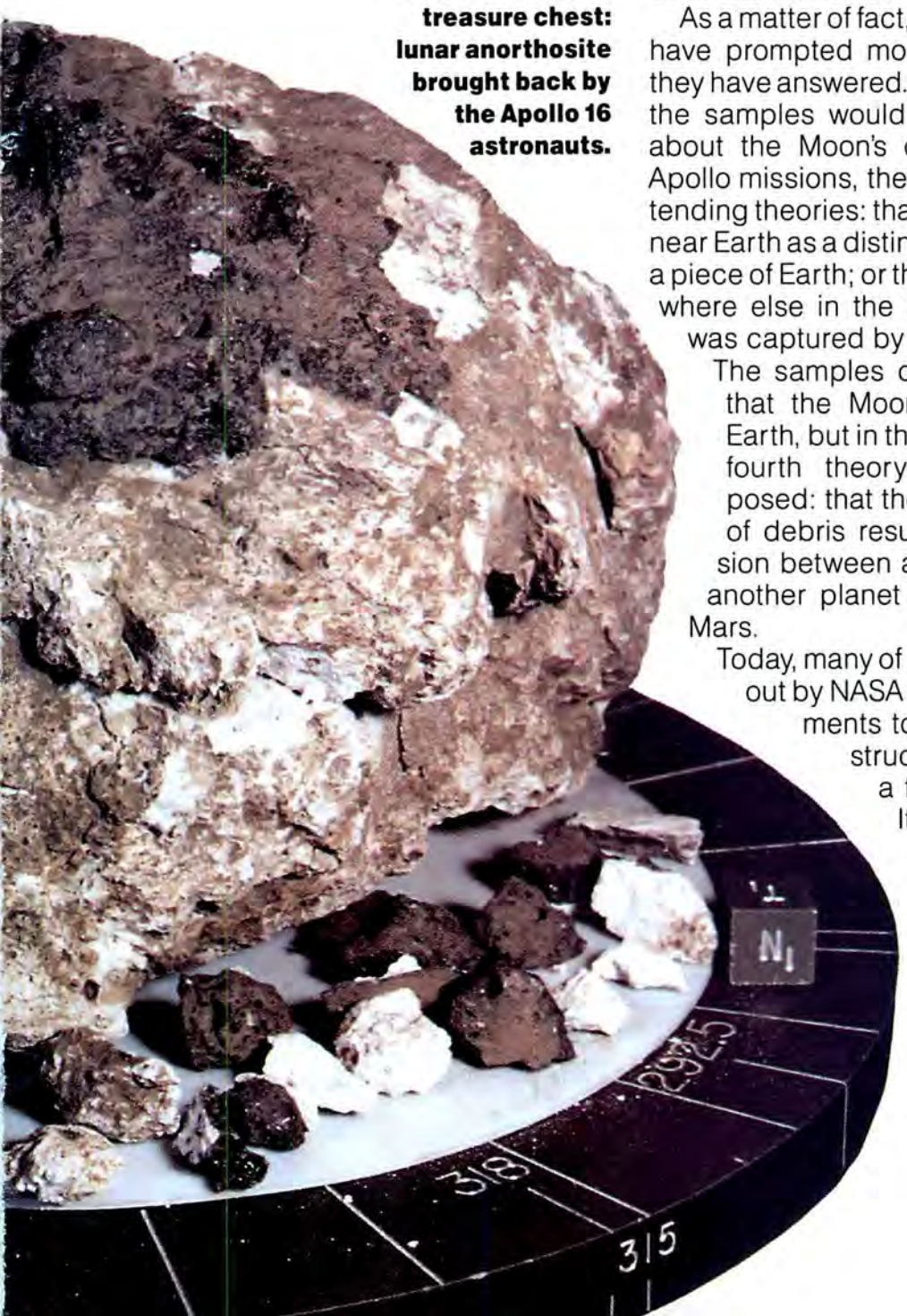
"He had rubbed a solution that had been exposed to Moonlight on this patient who had a massive shoulder injury, and ultimately the patient had been cured," Ryder says. "He didn't mention it in the letter, but it was clear from the photographs that the patient had surgery as well."

Even legitimate scientists sometimes give up when they get stuck in government red tape in the name of security, Ryder says. "It's still a pain, comparatively, to work on lunar samples," he points out. "If you want to work on a terrestrial volcanic rock, you just go out and get it and do with it what you want. To get a lunar sample, the paperwork and delays are annoying."

But the keepers of the Apollo treasure wouldn't have it any other way.

"It will always be a problem," Ryder adds, "because those samples are the legacy we have." □

Beth Dickey is a freelance writer in Melbourne, Florida who covers space and science topics for national wire services.



A "gem" from the treasure chest: lunar anorthosite brought back by the Apollo 16 astronauts.

L U N A

From Texas to Japan, planners are working to make sure that Apollo's fortieth *anniversary is celebrated on the Moon.*

By Miles Weiss and Greg Freiherr



It dominates the night sky, taunting those who can see but not touch it. For a short time—41 months, to be exact—the Moon was within our grasp. Then, just as suddenly, it was gone. Now some would have it back again.

During that brief period when the Moon was an inhabited place, NASA envisioned follow-on bases, with six people stationed on the surface for half a year. Their home would have looked more like a water tower than a lunar city. Now, 20 years after the first Apollo landing, ideas for establishing outposts on that nearby world are again bubbling to the surface. Some are primitive, almost Neanderthal: explorers living in caves, lunar villages built in tunnels and caverns. Others border on science fiction: Moonbases sprawling over the lunar surface, shielded from radiation by force fields.

Once again, NASA engineers—and others—are tinkering with ideas for using the Moon as anything from a scientific outpost to a training ground for Mars missions. Much of the technology for a return to the Moon is already in hand, developed for Apollo and Skylab, or for the shuttle and proposed space station.

"The object is to go back to the Moon—not to develop neat new technologies," says Robert Staehle, president of the World Space Foundation in Arcadia, California. "If you go back to the Moon quickly, but in a way that says you intend to stay, the technologies that make it easier and cheaper to get there will come along in due time."

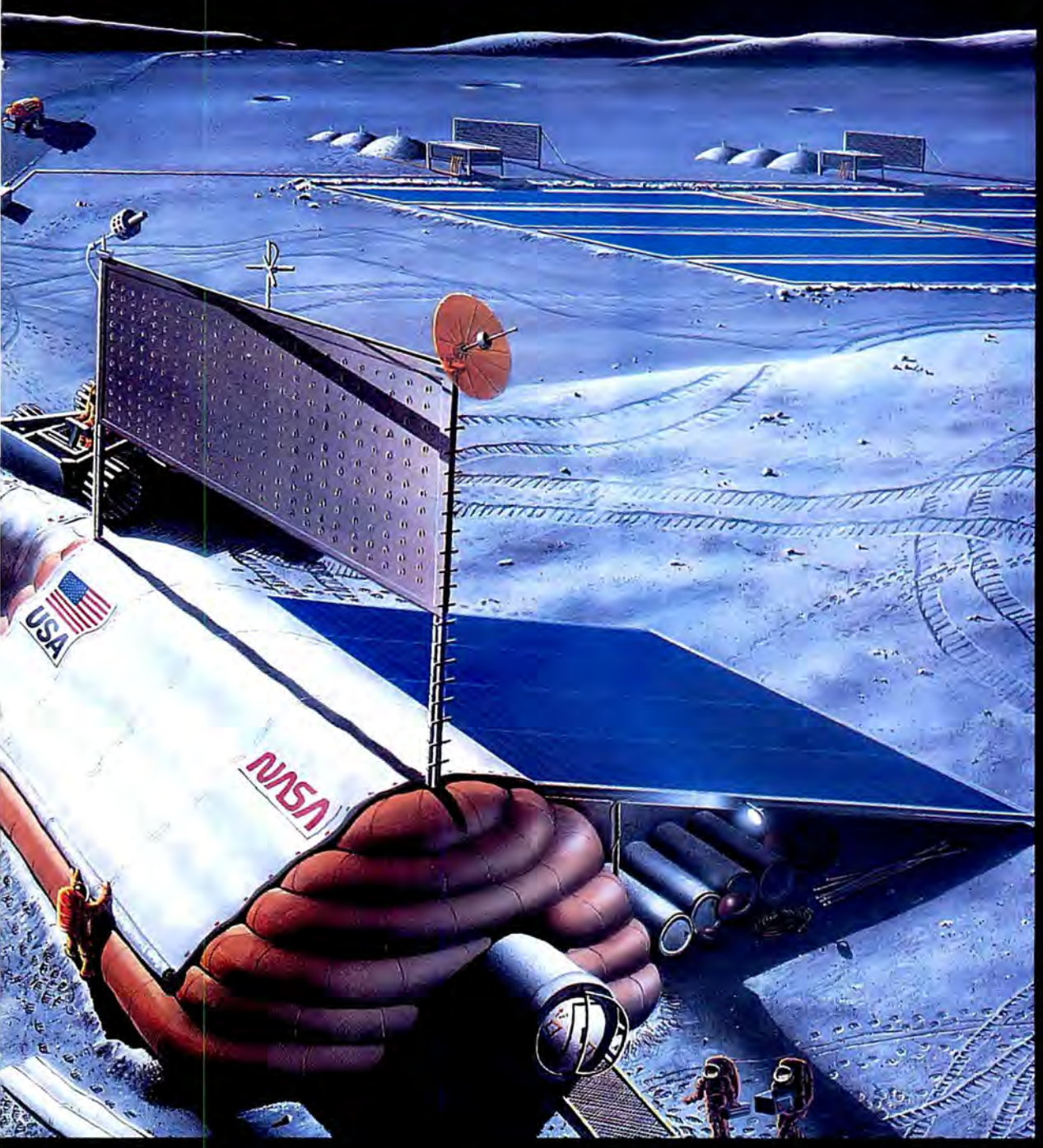
Rather than Americans racing the Soviets, engineers are competing among themselves to come up with plans for re-populating the Moon. Their ideas range from the simple to the complex, the academic to the commercial, the conservative to the devil-may-care.

Foremost in everyone's mind is the need to protect future astronauts from the blazing heat and abominable cold of the lunar day and night, as well as from meteors and lethal radiation. One solution would be a kind of extraterrestrial cave dwelling, built inside "lava tubes." These natural tunnels exist in Hawaii, Oregon and other regions on Earth where lava has spewed from volcanoes. Geologists believe that lunar rilles—beds of dried lava that criss-cross the Moon's surface—may in fact be collapsed lava tubes. Stronger, sturdier tubes, some of them hundreds of miles long, may be buried intact underneath.

Lava tubes would provide a natural shell for fragile structures built inside them. One idea is to erect a pressurized tent made from inexpensive plastics. "You could have a series of compartments made of plastic with doors and air locks," explains Fred Horz, a staff scientist in the Solar System Exploration Branch of NASA's Johnson Space Center in Houston. "You could put a whole production plant into the cave—lay out pipes and machinery like in a terrestrial factory."

If lava tubes are nowhere to be found, astronauts might make their equivalents. Conventional explosives, laid below the surface, might hollow out whole caverns. Or automatic tunneling machines sent ahead of the lunar settlers would melt the ground; researchers at Los Alamos National Laboratories in New Mexico are now studying such a tunneling machine, which

2 0 0 9



MIKE STOVALL/EAGLE ENGINEERING

An inflatable dome would be the centerpiece of a lunar outpost powered by huge solar arrays.

would use a nuclear generator to create heat. Melted lunar material would cool to form a glass surface along the sides of the tunnel, sealing the walls so the entire man-made cave could be pressurized.

For those who'd prefer not to live in Moon caves, there are plenty of ideas for lunar architecture. Modules similar to those proposed for NASA's space station Freedom could even be delivered to the Moon as shelters.

"The guys in accounting love the idea, because it means you can open a space station module assembly line and buy 20 instead of eight, which makes everything cheaper," says Wendell Mendell, chief scientist for lunar base studies at NASA's Johnson Center.

But people who are going to live and work on the Moon may not want to live in dwellings built for an orbiting space station. Gravity would make the accommodations inadequate, according to Larry Bell, chairman of the Houston firm Bell and Trotti, and director of the Sasakawa International Center for Space Architecture at the University of Houston. One problem would be the absence of a walkway, since astronauts in Earth orbit would simply float to their stations. Another would be the cramped sleeping quarters: in zero-g you can sleep on the ceiling, but in lunar gravity only the floor is available.

NASA is now in the early stages of redesigning these modules for use on the Moon. Nathan Moore of Johnson's Manned Systems Division has outlined two concepts for a "Hab/Lab" that would be divided into an upper crew level and a lower laboratory level. Installing a central corridor in the split-level module would leave more room for equipment, while a side corridor would make things roomier for the crew.

"The side corridor version is pretty loose on how it uses volume," Moore said. "The other is almost too densely packed. I think the optimum would be somewhere in between."

Other problems with lunar design might not be recognized until the modules were actually put on the Moon. "We know a lot about designing for zero gravity," Bell says, "but we know less about partial gravity."

What *is* known suggests that lunar bases could revolutionize architectural engineering. "The Moon has a very low gravity compared to Earth, and it is very quiet in terms of seismic activity," says Stewart Johnson, principal engineer for the BDM Corporation in Albuquerque, New Mexico. "So structures can be very lightweight. They would definitely appear flimsy by terrestrial standards."

Perhaps the flimsiest and easiest structure to build would be an inflatable Moonbase. The walls could be made of beta cloth, which is now used in space suits, or Kevlar, the stuff bullet-proof vests are made of. Once on the Moon, astronauts would just blow up their new homes and walk in. Dividing walls, floors and furnishings would add a touch of home. "It would be a more Earth-like environment than a small metal module," says Michael Roberts, an engineer in the Advanced Programs Office at Johnson.

Several designs for lunar "buildings" are being considered. The grandest is a sphere 52 feet in diameter, spanning four stories and providing the same amount of room as 11 space station modules. The sphere, which could house a dozen crew members, would have different facilities on each floor: crew quarters on top; recreational, health and eating facilities on the third; space and surface operations on the second; and mission operations, including laboratories, on the bottom.

continued on page 60



Nep at last!

After a journey of nearly three billion miles, Voyager 2 prepares for its last hurrah.

BY TONY REICHHARDT

Out there in the cold and the dark, not much changes day to day except the numbers, and the numbers, by all human standards, are incomprehensible. In the fifteen minutes it takes to read this article, Voyager 2 will travel ten thousand miles. By tomorrow it will have crossed another million miles of space, moving about twenty times faster than an M-16 rifle bullet. When it reaches Neptune in late August, the spacecraft will be 2,743,000,000 miles from home.

But those are human measures, and Voyager long ago left human measures behind. For more than a decade it's been out there at the edge, a survivor of the golden age when Mariner, Viking and Pioneer probes wandered the void exploring unseen worlds. After Neptune, wherever we go in the Solar System, we'll be going back. Until we send a robot to Pluto or discover planets around other stars, this is the last of the "firsts."

Although Neptune is easily seen with a telescope, no observer—not even Galileo, who recorded it in his notebooks in 1612—recognized it as a planet until 1846. Like Uranus, it consists of layers of ice and liquid surrounding a warm, rocky core. A thick atmosphere of hydrogen and helium is topped by a haze of methane gas, which absorbs red light and accounts for Neptune's blue-green color. (It might not seem that way if you were riding along with Voyager; the feeble sunlight would make the planet appear a soft gray.)

At Uranus, the methane haze presented Voyager's cameras with a nearly featureless turquoise ball. Neptune should be different: Scientists know already that the planet has enough internal heat to churn up storms and other weather systems.

Even before Voyager began to study Neptune intensively in early June, clouds could be discerned in the images—bright streaks that allow scientists to track wind speeds in the atmosphere. By January, Voyager's photos showed a dark band of haze around Neptune's south pole. By April, the pictures had revealed a dark blotch in the southern hemisphere, which scientists immediately likened to Jupiter's Great Red Spot.

Seeing this much detail while still so far from the planet "puts us far ahead of where we were with Uranus," according to Voyager's imaging team leader, Bradford Smith, and makes it nearly certain that Neptune won't be a dud for the cameras.

As Voyager speeds toward its destination, the photos it takes will be used to create "movies" of the circulating atmosphere. By the first week of August, the planet and its suspected ring system will no longer fit in the narrow- angle camera's field of view, and Voyager will begin to take overlapping frames to be assembled later into mosaic images.

Meanwhile, the radio astronomy antenna—one of eleven experiments onboard—will be searching for signs of a magnetic field. Ground-based observations hint that Neptune may have a more intense radiation field than we would normally expect for a planet four times the size of Earth. Voyager probably won't find



Voyager 2's photos of Neptune already were showing bright cloud features in January, when the spacecraft was still 185 million miles away.

tune

out for sure until a few days before closest approach.

Thanks to the Voyager missions, we now know that planetary rings are the rule rather than the exception in the outer Solar System. The rings of Jupiter, Saturn and Uranus all have their own pecularities, but Neptune's may be the most bizarre of all. In fact, the planet doesn't even appear to have continuous *rings*. All that appear from Earth are "arcs"—broken sections of rings with nearly empty space in between.

The most plausible explanation for these arcs is that the gravitational influence of some unseen moon, perhaps less than 200 miles in diameter, is disrupting the ring material so that it clumps together. (The Voyager project office even took the liberty of including this still theoretical moonlet in computer animations prepared before the August fly-by).

The mysterious arcs will be difficult to image, even for Voyager. The tenuous threads are believed to be around 1,000 miles long, five to ten miles wide, and less than a mile thick. They're also expected to be rather dark, so the ring arcs may not appear in Voyager pictures until a week or two before the spacecraft reaches its destination.

Emerging from below Neptune's equatorial plane on August 24, Voyager will zoom up and over the North Pole. At precisely 9 P.M. Pacific Time, it will fly past the cloudtops at a distance of only 3,000 miles—closer than the probe has come to any object since leaving Earth 12 years ago. As it skirts Neptune's clouds, Voyager also will make its first passage through a planet's auroral zone.

Four hours earlier, on the way in, it will have snapped its best images of Neptune's smaller moon, Nereid. Taken at a range of nearly three million miles, the resolution won't be sharp compared to previous Voyager photos, but the pictures may show any light and dark variations that exist on the surface.

More eagerly awaited is the encounter with Neptune's large moon, Triton, which takes place five hours after Voyager's closest approach to the planet. Scientists believe Triton is about the size of our own Moon, although its diameter is poorly known. Lakes of liquid nitrogen were once thought to exist on its icy surface, but that's no longer a fashionable theory.

With any luck, we'll find out from the photos Voyager takes as it passes within 25,000 miles of Triton. When Voyager photographed Saturn's moon Titan in 1980, the pictures were disappointing: the surface was obscured by a reddish-orange haze caused by the action of sunlight on the methane atmosphere. But since Triton is much farther from the Sun, photochemical activity should be less, and project scientists are confident that at least some of the surface will be visible.

If their theories are correct, Voyager's images should show a reddish surface coated with hydrocarbon sludge that rains down from the atmosphere. Since those hydrocarbons are the stuff of life, exo-biologists will be waiting for the results just as eagerly as the geologists.

Heading into the Neptune encounter, Voyager 2 has surprisingly few problems. Among other minor glitches, dust in the narrow-angle camera leaves doughnut-shaped spots in the images, and the spacecraft's primary radio receiver failed years ago. But the spacecraft is remarkably healthy for an aging explorer, and engineers expect it to last well into the next century. In case anyone misses the point, the project is now called the "Voyager Neptune Interstellar Mission."

All computer sequences for the August fly-by were finished months ago, all procedures and potential problems ironed out. Project managers even brought in a consultant to advise on computer security, at a time when "viruses" and hacker saboteurs were in the news.

To squeeze every bit of data out of Voyager's faint radio signals (which will take four hours and six minutes to reach Earth at the time of the encounter), NASA will be "borrowing" the Very Large Array of radio antennas in New Mexico, along with Japanese and Australian dishes to supplement its own global Deep Space Network, which has itself been upgraded. Voyager's onboard computers have been re-programmed extensively over the years, so that in terms of software and procedures, it is in many ways a different spacecraft from the one that was launched in 1977.

The original science planning meetings for Voyager took place in 1972, at a time when astronauts were still on the Moon. Many of the scientists who gather in Pasadena this August for their sixth planetary encounter have gone gray together. Only five of the original group of eleven investigators are still on the experiment team. Two have retired. One has died.

Meanwhile, Voyager keeps plodding toward Neptune, faster than a speeding bullet, a million miles a day. □

BACKYARD UNIVERSE

Where The Boys Were

A telescopic tour of the Apollo landing sites

▼ ▼ ▼

By Patricia Barnes-Svarney

You can admit it now. It's been twenty years.

You can confess how you stayed up until the wee hours of the morning, watching Neil Armstrong put the first human footprints on the Moon. That tears came to your eyes, just like Walter Cronkite and Wally Schirra. And that, under the cloak of darkness, you took your telescope out into the warm July evening and stared—hoping to see a ray of sunshine reflect off the lunar lander. I confess. I did it, too.

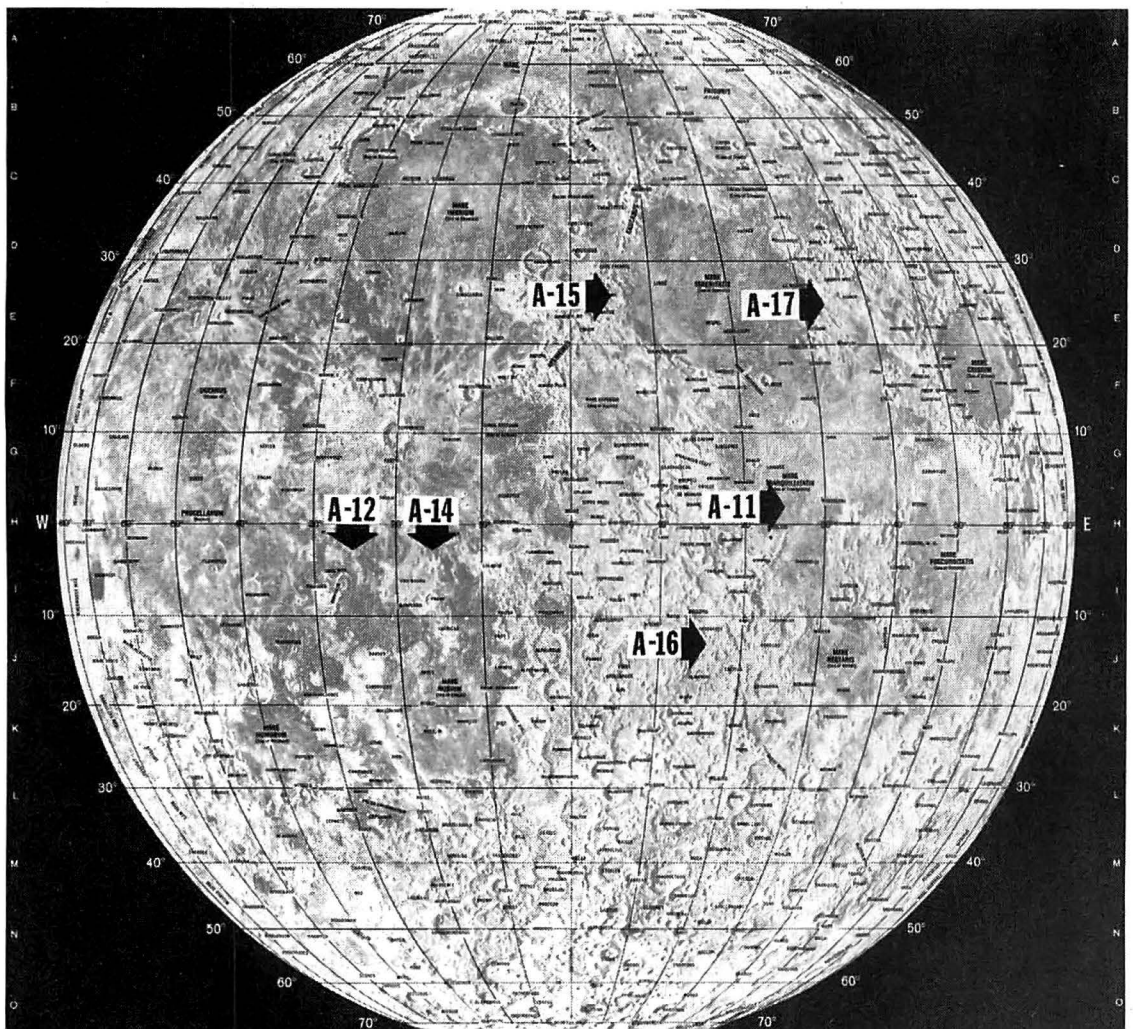
In reality, my 4.5-inch Newtonian reflector couldn't see the lunar module, much less Neil, Buzz or the other Apollo crews. Neither could the 16-inch Cassegrain at the local observatory, nor the 200-inch on Mt. Palomar. But that doesn't mean you can't explore the general vicinity of each Apollo landing site using your backyard telescope.

The approximate touchdown spots for Apollo 11 through 17 (minus the aborted Apollo 13) zigzag across the face of the Moon's near side. They cover the main types of lunar surface: rugged highlands to smooth *mare* "seas"). The best time to view a particular site is when the terminator (the line between darkness and sunlight) is near to it, because shadows show the greatest contrast. To see all of the Apollo sites at once, the full Moon is best—but the details will be washed out by the intense light reflected off the lunar surface.

To start your search, find a good map of the full Moon. Most libraries will have one, with most of the mare and major craters labeled. Use a map that has north at the top; but remember that map projections are distorted, and that your image through the telescope (not binoculars) will be upside down.

The Apollo 11 site is in the Sea of Tranquillity (Mare Tranquillitatis). Aim your telescope at the lower southwest corner of the sea. There the footprints of Armstrong and Aldrin probably will lie undisturbed for millions of years.

Six expeditions landed on the Moon from 1969 to 1972, all on the near side.



The second lunar landing, Apollo 12, was in November 1969, in the southeastern part of the Ocean of Storms. Find the crater Lansberg, then look just to the southeast. Only 600 feet away from the astronauts' lunar module sits Surveyor 3, a picture-taking robot that settled on the Moon in 1967.

Apollo 14 landed on February 5, 1971 in the hills north of the wide but shallow Fra Mauro crater. North of the Sea of Clouds, you should easily see the crater Parry; Fra Mauro is just above it. The Apollo 14 expedition gave way to the only round of golf played on the Moon, as Alan Shepard made his ultimate "sand-trap" shot.

Six months later, the Apollo 15 crew used the first Moonbuggy to explore an area around a 15,000-foot peak named Mt. Hadley, located in the Apennine Mountains. The highlands are the dividing line between the Sea of Serenity and the Sea of Rains. Look for Mt. Hadley near the break between the Apennines and the Caucasus Mountains.

Apollo 16, in April 1972, was one of the most ambitious missions of the program, landing in the Descartes area of the lunar highlands, west of the Sea of Nectar. Center on the crater Kant, then move west just a little. You're in Descartes.

Perhaps the most memorable Saturn 5 liftoff came on the last lunar landing mission, Apollo 17, which also was the first nighttime launch. Touching down in the Taurus-Littrow area southeast of the Sea of Serenity, the astronauts covered the most distance ever in their lunar rover. Look on the eastern side of Serenity, south of the crater Romer. That's the general vicinity of the final Apollo expedition. Locating these lunar landing sites yourself is a challenge everyone should undertake at least once, and not just to test the optics of your telescope. It's more the idea that somewhere "up there," twelve humans galloped, golfed and named everything in sight while we stayed back on Earth, living vicariously through their adventures.

I confess...I did it, too. □

NSS MEMBERSHIP APPLICATION

Signing up for membership in the National Space Society visibly declares your support for vigorous and comprehensive space activities. It will not happen unless *you* make it happen. Joining the National Space Society is your first step toward active concern that it does happen!

MEMBERSHIP BENEFITS

In addition to supporting our efforts on behalf of an active space program, your benefits will include:

★ **Ad Astra** —Your very own monthly publication with up-to-date inside information on space activities

★ Participation in national, regional and local meetings and workshops

★ Unique educational tour opportunities

★ Community action through volunteer opportunities in our chapter network

★ Discounts on valuable space merchandise and books

★ Exclusive Space Hotline and Mir Watch for up-to-the-minute news about the space program

☐ **YES!** Sign me up to participate in our Space Program by enrolling me as a member of the National Space Society at $30 annual regular dues.

☐ I am under 22 or over 64 and am therefore eligible for the special annual rate of $18. My age is _____

(NSS is a nonprofit, publicly supported educational organization recognized under IRS Code section 501(c)(3).

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

You may pay by credit card by completing the following:

☐ Visa ☐ Mastercard ☐ Diners ☐ American Express

CARD NUMBER _____ EXP DATE _____

SIGNATURE _____

(Note: dues must be paid in $US; outside of North America, please add $5)

FR4

☐ Please bill me

NATIONAL SPACE SOCIETY • 922 PENNSYLVANIA, SE • WASHINGTON, DC 20003 • 202/543-1900

Your stamp will save Society funds!

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 13587 WASHINGTON, D.C.

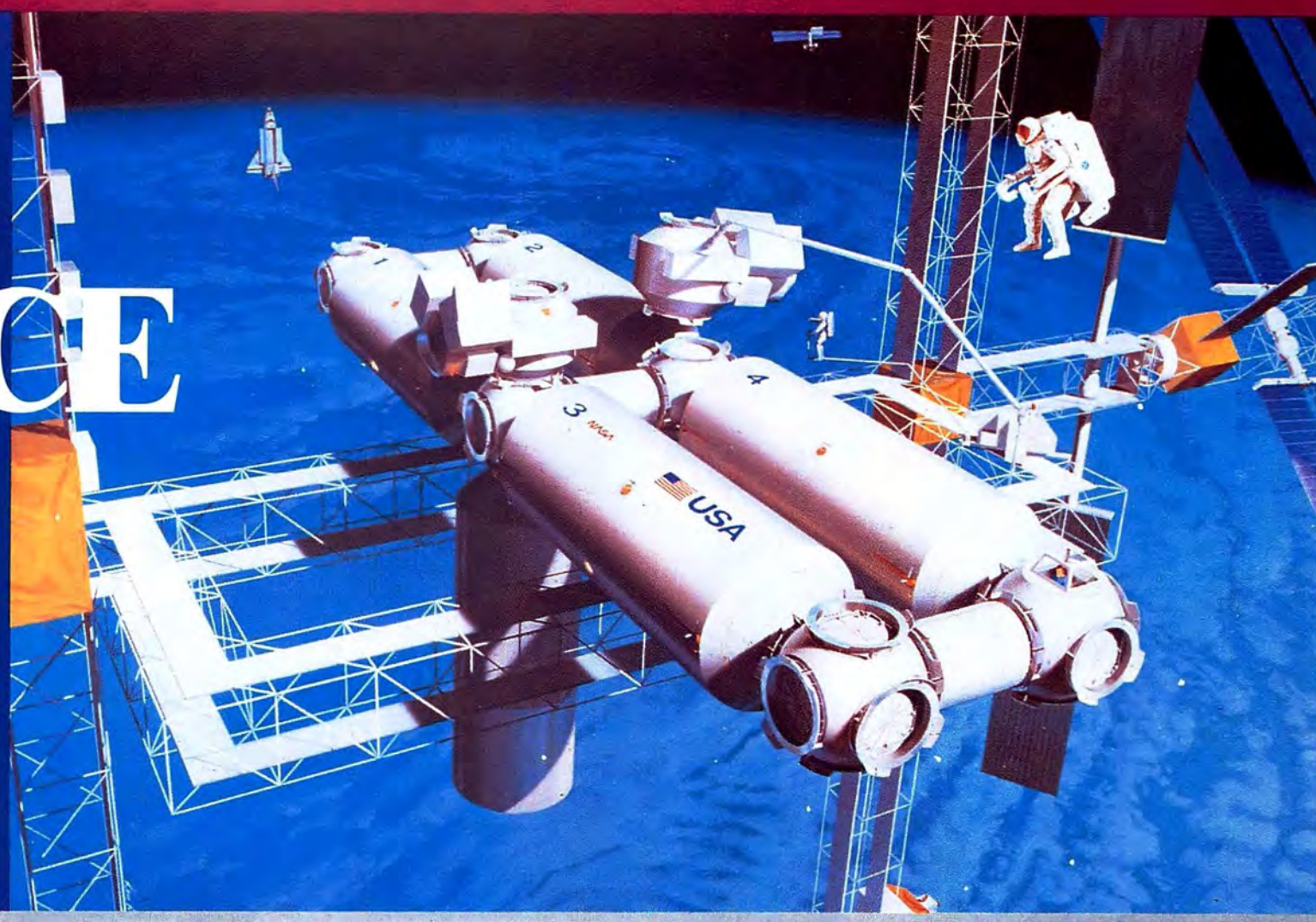
Postage will be paid by Addressee:

NATIONAL SPACE SOCIETY

Membership Department
P.O. Box 96651
Washington, D.C. 20077-7475

SPACE

...the final frontier



Our space program is a vital part of a hopeful future. More than any single program, it will determine what our children will inherit tomorrow.

The **NATIONAL SPACE SOCIETY** wants a vigorous, comprehensive space program that will provide benefits for all humanity while stimulating progress in all aspects of our lives. We want a space program that belongs to everyone: businessmen and homemakers as well as engineers and astronauts.

Only assured access to space technology and the development of space resources will help us create a new Renaissance that will help us overcome major problems on a planet-wide scale.

Members of the **NATIONAL SPACE SOCIETY** are concerned enough about the vitality of the space program to take an active role in monitoring and influencing its direction. Join us and through our non-profit, educational activities you can begin to make the hopeful future a reality.

The **NATIONAL SPACE SOCIETY** objectives include:

★ Providing broad, visible public support for a comprehensive space program.
★ Creating opportunities for the public to become involved in the space program.
★ Encouraging greater involvement by private enterprise in developing the space frontier.
★ Seeking the maximum government support for research to advance the technology needed to live in space.
★ Reinvigorating the economy by maintaining competitive leadership in space manufacturing.
★ Stimulating interest in math and science by creating employment in space careers.

You can help right now! Join us today by sending in your $30 membership dues, $10 of which is for a subscription to Ad Astra, the monthly magazine of the National Space Society.

NATIONAL SPACE SOCIETY 922 PENNSYLVANIA AVE, SE • WASHINGTON, DC 20003 • 202/543-1900

Rare Space Materials

USSR SPACE PATCH COLLECTORS SET
High quality, genuine Soviet designs. Set of 5 patches includes: USSR Space Insignia, Coat of Arms, Soyuz Crew, Intercosmos, Intercosmos (cyrillic variation). #**PH1** $34.95 (s/h $1.00)



DESKTOP DISPLAY SCALE MODELS
Limited edition-highest quality. Completely assembled and finished with authentic markings. Includes varnished wooden base.
Small Shuttle, tank/boosters (shown). 1/200, 11" x 4 1/2", #**M1** $49.95
Large Shuttle, tank/boosters. 1/100, 25" x 9", #**M2** $189.95
Medium Orbiter, 1/144, 10" x 6 1/4", #**M3** $47.50
Large Orbiter, 1/100, 14 1/2" x 9 1/4", #**M4** $89.95
Orbiter w/open cargo doors, 1/100, 14 1/2" x 9 1/4", #**M5** $149.95
(s/h 4.00 each)





SPACE PIN-COLLECTORS SETS
Jewelry-quality, official crew-insignia designs. Complete, special edition sets. Genuine cloisonne.
Mercury Program Series (7 pins). #**C1** $34.95
Apollo Program Series (17 pins). #**C2** $85
Shuttle Program Series (thru STS-30). #**C3** $144
Intercosmos Series-Soviet Block (18 pins). #**C4** $125
Official Pin Collectors Album. #**C5** $34.95
(s/h 2.00 each)





FISHER SPACE PENS
The actual pen of the astronauts. Writes upside down, under-water, in freezing & boiling temperatures.
Astronaut Pen: (displayed in gold–available in chrome only) #**P1** $12.95
Bullet Pen w/Shuttle: #**P2** $16.95 (s/h 1.00)



COLOR SLIDE SETS
Specially compiled by Final Frontier's photo editor. Dramatic, full-color images.
Apollo 11 – Moon landing (20 slides). #**S1** $14.95
Manned Launch Vehicles (20 slides). #**S2** $14.95
The Best of the Shuttle Program (40 slides). #**S3** $24.95 (s/h 1.50 each)





NEW AGE SPACE MUSIC
Two bestselling CD's from Atlanta planetarium composer John Serrie. Highly recommended for music listeners who like to drift into space. **"And The Stars Go With You"** CD – #SM1, Cassette – #SM2
"Flightpath", CD – #SM3 Cassette – #SM4
Compact disc – $14.95 Cassette Tape – $9.95 (s/h $1.50)

Order now!

To order by phone: 612-332-3001
For speedy delivery

Final Frontier Space Materials
2400 Foshay Tower
Minneapolis, MN 55402

Name _____
Address _____
City _____ State _____ Zip _____
Daytime Telephone No. _____

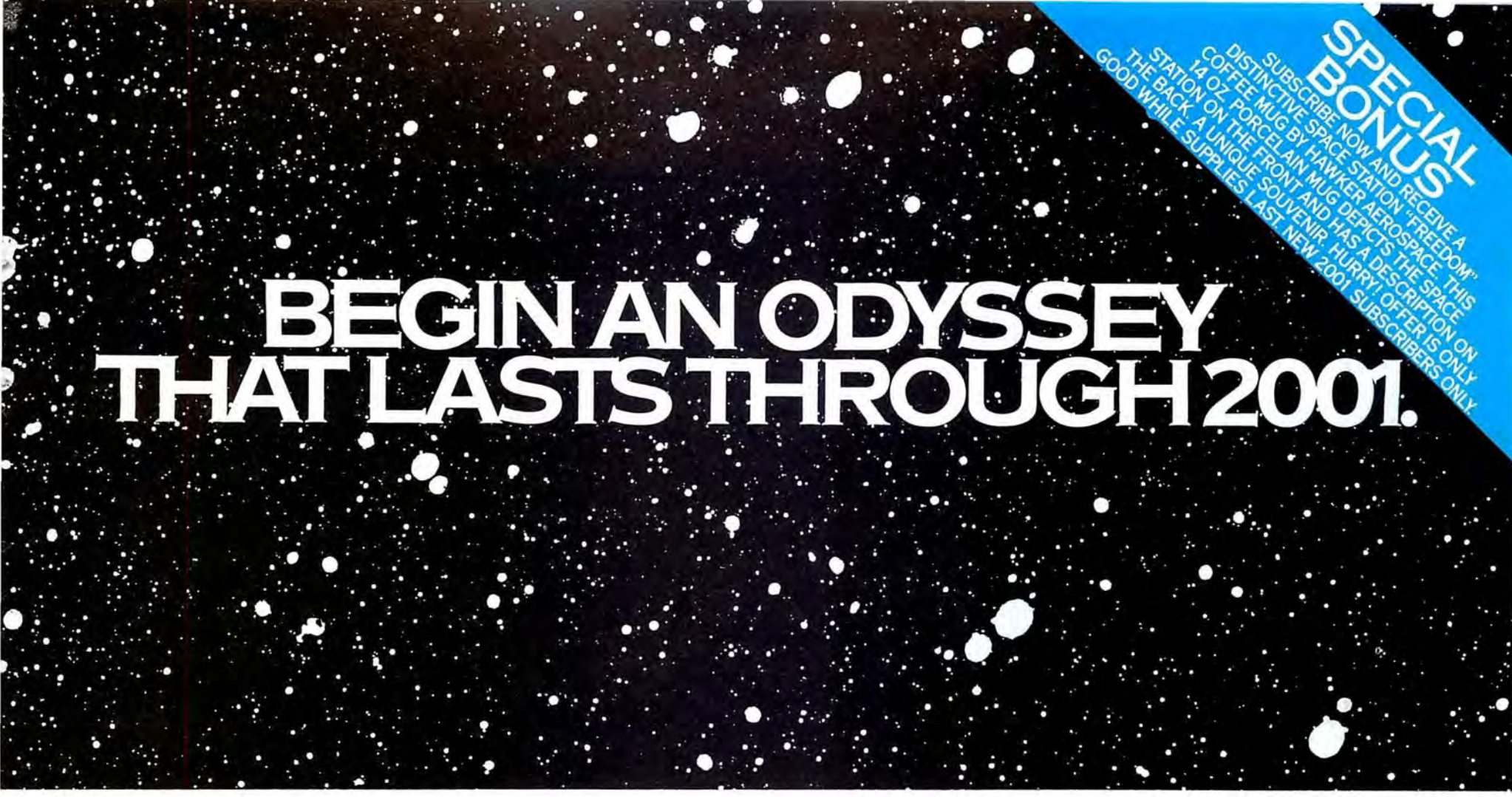
Method of payment

☐ Check/Money Order ☐ Visa ☐ MasterCard ☐ American Express
Credit Card No. _____ Exp. date _____
Signature _____

Qty.	Name of Item	Item #	Price each	S/H	Total
	Information			**Grand Total**	

Allow 3-4 weeks for delivery. Some items may take longer due to availability.
For Canadian surface shipment double S/H, overseas triple.

Call for overnight delivery prices!
0789



RECEIVE FINAL FRONTIER INTO THE 21st CENTURY FOR JUST $99.

Final Frontier has lift off. We've soared beyond our most optimistic projections. And now we're planning for the year 2001.

This is an opportunity for true believers — people who've always championed space exploration; people who believe in the magazine.

For less than a hundred dollars, you can have Final Frontier delivered to your front door through December, 2001.

You'll be aboard through the second great wave of space exploration. You'll be the first to hear about astronomical events, human-made or otherwise.

Your subscription saves you over $150 off the newsstand price — and almost half off the regular subscription price. You save even more when you consider inevitable price increases. And your savings will increase dramatically when we become a monthly magazine.

Your $99 also lends Final Frontier a boost at this critical time. Your subscription will allow us to reach more space enthusiasts, publish more frequently, and raise the magazine's standards even higher.

All of which should help us reach our ultimate goal — seeing more gleaming silver ships leave the boundaries of earth.

Subscribe to Final Frontier through Kubrick and Clarke's appointed year. And help us build a ladder to the stars.

YES, I WANT TO SUBSCRIBE TO FINAL FRONTIER THROUGH DECEMBER, 2001, FOR THE LOW PRICE OF $99–THAT'S 60% OFF THE NEWSTAND PRICE.

☐ *My payment is enclosed* ☐ *Please bill me* ☐ *Charge to my credit card*

☐ *VISA* ☐ *MC* *Account #* _____ *Expiration date* _____

Signature _____ *Date* _____

Name (please print) _____

Address _____

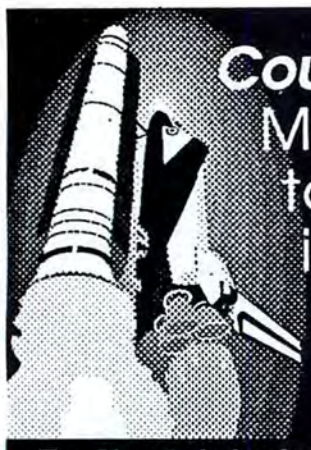
City _____ State _____ Zip _____

VH9

Fill in this coupon, clip it out, and mail it to:

FINAL FRONTIER MAGAZINE
2400 Foshay Tower
Minneapolis, Minnesota 55402

FOR CANADIAN AND FOREIGN SUBSCRIPTIONS, PLEASE WRITE FOR FURTHER INFORMATION.
TO ORDER BY PHONE, CALL: (612) 884-6420.



Countdown Magazine takes you into orbit --and beyond!

The Shuttle is back, launching important missions. ***Countdown*** monthly magazine, with half a decade of experience covering the space program, takes you aboard for every flight. If you like more detail than newspapers and TV provide then ***Countdown*** is for you.

Free issue offer:
If you aren't fully satisfied with your 1st issue, cancel and pay nothing.

You pay only $19.95 for one year— 26% off our cover price.

Send order to:
Countdown
Dept. 52
Main Stage Publications
P.O. Box 216
Athens, OH 45701

Please enter my subscription to *Countdown:*
One year (12 issues) for only $19.95
($25 foreign, $45 overseas Air Mail)

___ Payment enclosed ___ Please bill me
(U.S. funds only, please)

Name_____
Address_____
City_____ State_____ Zip_____

FLY A **MMU**



Fly action-packed ZERO-G® sportswear featuring the MMU and the Space Shuttle. Inspired by today's high-tech computer graphics, these compelling designs bring to life the power and grace of each spacecraft. Our Shirts and Sweats are not only worn by the pilots of these dynamic spacecraft, but by the engineers as well! Great for any aviation enthusiast!

Call or write for FREE full-color catalog on this unique line of 100% GUARANTEED Shirts and Sweats.

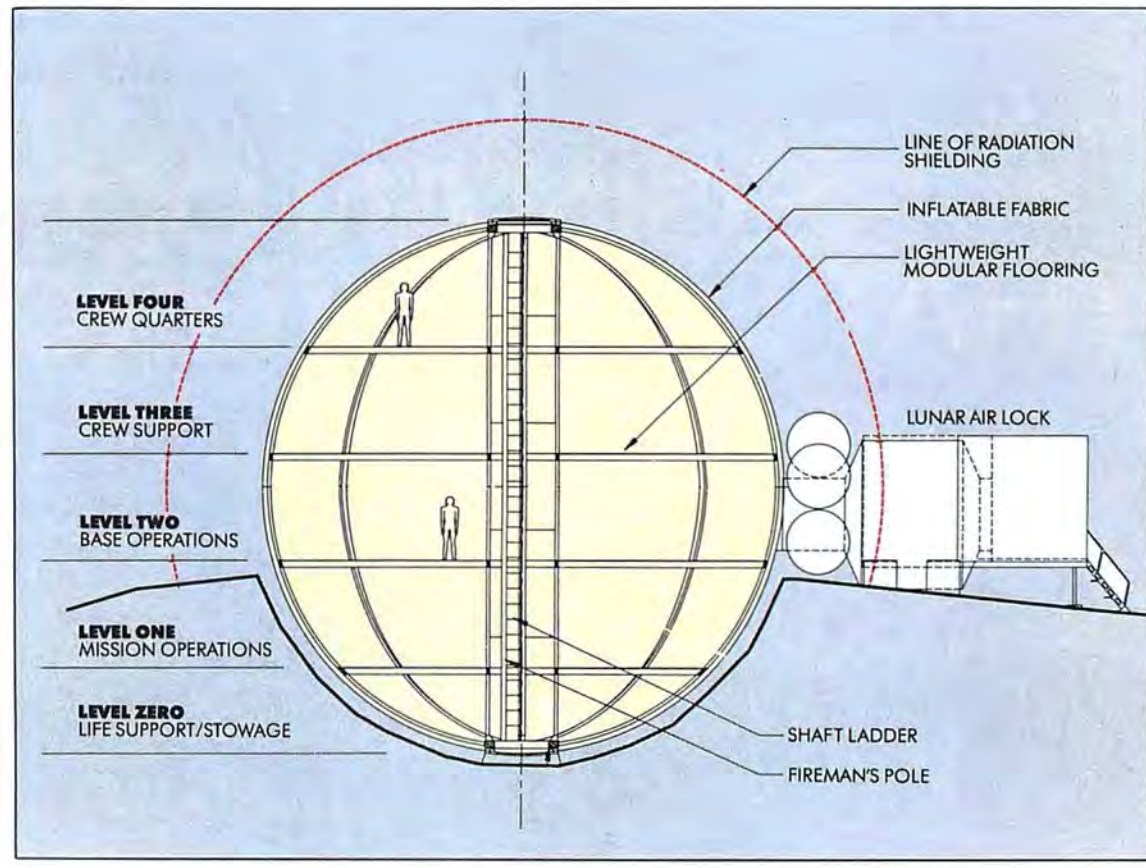
Call TOLL-FREE!
1-800-272-7171

BLACKBIRD®
AEROSPACE SHIRTS
BOX 8607, DEPT. FF,
SCOTTSDALE, AZ 85252

(602) 966-7613 International
(602) 966-7384 Arizona Residents

Luna 2009

continued from page 53



KRISS KENNEDY/JOHNSON SPACE CENTER

The crew would travel between floors using a central "stair well" running the height of the sphere. There would be three exits, including an airlock where pressurized rover vehicles could dock—allowing astronauts to leave the sphere without a spacesuit—and another airlock for lunar shuttles.

"For protection, the base would be set in a crater, either existing or man-made," explains Kriss Kennedy, an aerospace engineer at Johnson. "Coiled around the outside to provide a protective shield would be a sock filled with lunar soil."

Lunar dirt is commonly used in the design of nearly all proposed shelters, even those modified from space station modules. In their case, dirt would be heaped over the top and plowed up along the sides of the module.

But using soil as shielding material is only one way to protect Moon explorers from the harsh lunar radiation and temperature extremes. Some engineers think that our first permanent base on another celestial body should have a little more pizzazz—like a force field to repel dangerous radiation. Magnetic fields are now being used at high-energy research facilities on Earth to guide beams of energetic matter. Their use on the Moon is admittedly a stretch of the imagination, but an intriguing one.

"This is not something that physicists might agree is practical," says Michael Duke, chief of Johnson's Solar System Exploration Division. "But if you are able to build big superconducting magnets and operate them at modest temperatures, you may be able to build shields against the radiation environment on the Moon."

Above: A cross-section of a proposed lunar habitat. Below: An astronomical observatory on the Moon's far side.



PAT RAWLINGS/EAGLE ENGINEERING

At present, however, lunar bases are being designed around more near-term technology, as well as more near-term goals. The construction of a lunar observatory is a good example of an obvious, early use for a Moonbase, and NASA's Office of Exploration has included such a facility as part of its evolutionary strategy for the Moon.

Setting up a radio observatory might start with a single telescope on the far side of the Moon. Wire could be strung from rim to rim on a nearby crater, forming a huge dish that would dwarf any telescope on Earth, yet would require only about 4,000 pounds of mass, compared to 100 times that amount for a ground-based dish. Astronauts would visit now and then to check the facility and collect data.

At the other extreme is a deluxe version called the Lunar Optical-Ultraviolet-Infrared Synthesis Array (LOUISA) that BDM Corporation wants to build. LOUISA would be the 21st century successor to the Hubble Space Telescope; it would consist of more than 40 instruments deployed over a six-mile diameter on the Moon, and would be able to "resolve a dime at the distance from the Earth to the Moon," says BDM's Stewart Johnson.

The expense would be high, the construction and maintenance complex. But the payback could be worth it: views of distant stars and planets in the earliest stages of formation. The airless skies of the Moon, free of atmospheric pollutants and—on the far side—free of competing radio signals, are the primary attraction that the Moon holds for astronomers. That same quality, specifically the freedom from radio noise, makes it an ideal place to listen for radio signals from extraterrestrial civilizations.

The Moon's lack of an atmosphere also attracts high-energy physicists. "People have talked about putting an accelerator around the lunar equator," says Alan Binder, a planetary scientist at Lockheed Engineering and Science Corporation in Houston. According to Binder, a lunar accelerator with a 60-mile diameter could be built with relative ease. Gone would be the need to establish and maintain the vacuum critical for accelerating high-energy particles.

Moon-based experiments might also detect gravity waves emitted by Earth. A series of lasers and mirrors spread across a 60-mile diameter crater might answer questions about this mysterious natural force. Life scientists would like to study another basic force—magnetism. On the Moon, which has no magnetic field, they could test age-old hypotheses: whether magnetic fields actually help heal bones; whether plants and animals need magnetic fields to reproduce; and whether tiny pulses in a magnetic field help control bodily processes.

Geologists hope the Moon will provide clues as to what causes seismological quakes. They envision a vast network of 30 to 40 geophysical stations to study the Moon's heat flow and seismic activity. Most of these stations, like observatories on the far side, would be automatic. Astronauts from a lunar base would travel around on wheeled rovers, or bound from station to station aboard rocket-powered hoppers.

But what if experience shows that the Moonbase staff can't handle all these tasks themselves? "People working from a lunar habitat could stay in their environmentally controlled work area and remotely operate mobile robots working on the surface," says William R. Hamel, director of the telerobotic system section at the Oak Ridge National Laboratory in Oak Ridge, Tennessee.

Engineers at Battelle Memorial Institute in Columbus, Ohio have proposed a six-wheeled robot to help set up and maintain an array of up to 600 radio antennas on the far side. The robot, measuring about 14 feet long, six feet wide and six feet high, would have two arms mounted near its front and a cart-like payload bay to carry equipment. It would run on power from four nuclear-powered generators, backed up by lithium batteries.

Built for durability, the robot could operate up to ten years in the harsh lunar environment. In that time it could travel up to 3,000 miles, at a peak speed of about two miles an hour.

The Battelle robot is just one of a legion of machines proposed for the Moon. "There will be a tremendous amount of teleoperated activity," says Gregg Maryniak of the Space Studies Institute in Princeton, New Jersey. Most of the robots will be conservative in design, using wheeled vehicles or "endless track" crawlers. But some may be very different.

Several engineering teams are working on mechanical walkers that could venture into terrain where wheeled vehicles might become trapped. These walkers might cross rough, hilly surfaces that could tip a conventional rover, or step over holes that could permanently capture a wheel. A legged vehicle could "feel" its way ahead, crouching forward when going up a hill or stepping through soft soil until it hits a hard surface.

TITAN III, a four-legged walker, is already high-stepping its way around a



"PALACE CITY"
Artist: Gary Meyer.

Limited edition of 500 signed and numbered lithographs.

Select numbers are still available.

We also offer limited edition, fine art prints presented in museum quality framing by world-renowned artists:

Frank Frazetta
Gerry Grace
Charles Wildbank

An aggressive addition to your investment portfolio! Many of our limited edition prints have nearly tripled in value since their release.

Don't pass up this investment opportunity. Contact us today!

R.G.B. Investments™

7003 Whitsett Ave.
N. Hollywood, CA 91605
(818) 503-9714

"PALACE CITY" ©1986 L.Ron Hubbard Library All Rights Reserved

laboratory at the Tokyo Institute of Technology in Japan. Martin Marietta Space Systems in Denver has designed a "walking beam" that travels on seven telescoping legs, and a six-legged robot called AMBLER is being tested at Carnegie Mellon University in Pittsburgh.

AMBLER stands 19 feet tall "and looks like a big spider," according to Dave Lavery, a robotics specialist at NASA Headquarters in Washington, D.C. The purpose of the research, he says, is "to prove or disprove that we can build a device that has at least its own locomotion through an unknown environment."

Each of the proposed lunar robots would be equipped with some degree of artificial intelligence and an elaborate array of sensors so that they could avoid or escape from trouble themselves. This self-reliance would be especially valuable on the far side of the Moon, where contact with human operators might be maintained only sporadically through lunar orbiting satellites.

Drawing up sketches of lunar bases and their components is a necessary first step toward settling the Moon permanently. But deciding how to integrate and actually build the many different elements is an equally important problem.

According to NASA's Mendell, the solutions probably will not—and probably should not—come from the minds of government officials. "If you look at a lunar base, it has vehicle engineering, it has industrial processing, it has warehousing, piping, power generation and distribution, and surface transportation," he says. "If you want to build something with all those aspects, where would you go in the Yellow Pages? You wouldn't go to NASA. You'd go to the private sector—to construction companies."

Private firms are already lining up. The American Society of Civil Engineers in New York City has even formed a task force to prepare design criteria for lunar base structures. The emerging field has been labeled "astrotectonics" —Greek for "starbuilders."

In fact, competition to put up the first structures on the Moon could become fierce. "Will the first corporations who get to the Moon say they are the owners?" asks Wendel Wendel, whose name is not to be confused, but often is, with Mendell's. Wendel is president of Star Net Structures Inc. in West Babylon, New York, a firm that specializes in the design and construction of extraterrestrial facilities. His company and several other American firms have teamed up with Shimizu, the Japanese construction giant, to draw up plans for an ambitious lunar construction effort.

The firm has set 2004 as the year it will start to build on the Moon. The research and development work is now being done by Shimizu's Space Project Office, which includes more than 20 specialists with expertise in areas ranging from nuclear engineering to urban planning.

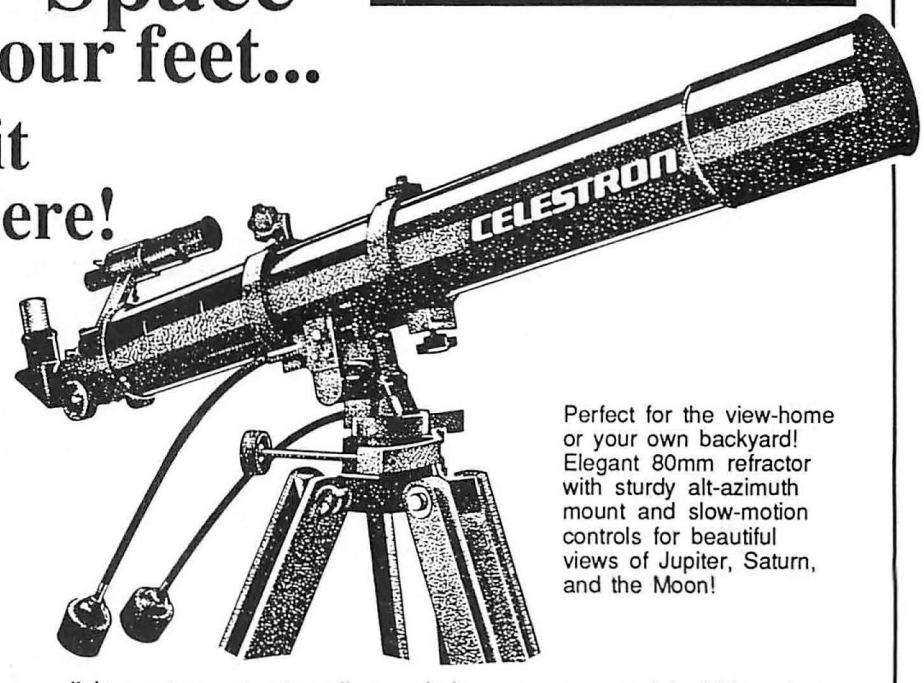
Several concepts are being considered, including a plan to build, using native lunar materials, modules weighing 30 tons on the Moon, and move them with automated transporters to construction sites. These hexagonal modules would have open sides that could be fitted with detachable panels. The base could consist of many small rooms or an open honeycomb-like structure. A large mobile crane would lift the modules off transporters and link them, and concrete would be poured to seal them together.

Other potential lunar operations include a "refinery" that would extract oxygen from lunar soil and liquefy it for use in rocket engines. Houston-based Carbotek, Inc. is designing such a liquid oxygen base, incorporating a num-

Outer Space
starts at your feet...
We take it from there!



A reflecting telescope of 114mm aperture. Equatorial mount with slow-motion controls. 900mm focal length, yet easily portable. Tracking motor available.



Perfect for the view-home or your own backyard! Elegant 80mm refractor with sturdy alt-azimuth mount and slow-motion controls for beautiful views of Jupiter, Saturn, and the Moon!

Once upon a time...

You had an interest in astronomy. You found the night sky exciting. Mystifying! So you bought a typical "first telescope" at the department store. Soon, excitement turned to dismay as you learned the telescope couldn't deliver all it promised. So you sold it, or put it in the attic. And, disappointed, you forgot the cosmos.

It doesn't need to be that way!

Select one of our quality telescopes and you'll immediately notice they differ greatly from so-called "department store" models... ours work! We also offer several excellent "how-to" books to help you get started. Order our catalog TF-89 today, $1.00.

scope:source
101 WEST MAIN ▪ P.O. BOX 2001
ARDMORE, OKLAHOMA 73402
405/226-3068

ber of features into the design that would minimize the weight of components delivered to the Moon.

Carbotek's Chairman, Michael Gibson, says "It's hard to imagine a commercial payoff" in operating the plant, but adds that it has important potential, because it would reduce the amount of fuel that would have to be hauled through the Earth's atmosphere to fill spacecraft in orbit.

Mining camps might take the lunar economy one step further, if other useful materials are found on the Moon. One candidate material is helium-3, which is not found on Earth but is plentiful in lunar soil. Scientists believe that this particular isotope of helium would make an ideal fuel for future nuclear fusion reactors. Lunar silicon and aluminum might also be extracted for use in constructing huge research and power platforms that would circle the Earth.

An advanced base with all these activities going on would need power, and lots of it. Lunar dwellers might then turn to a private utility company to meet their needs. As part of its Lunar Energy Enterprise Study, NASA has begun discussions with representatives from several private companies, including Citicorp, Bechtel, Inc. and Merrill Lynch, to hash out the concept. A key task is to determine the economic feasibility of different power options, including a fresh look at some old ideas, such as building a solar power satellite from lunar materials. The ultimate goal is to identify lunar industries that would attract private sector investment.

But there are some who have grown tired of the studies, the negotiating and the endless planning. They want a lunar base— and they want it done quickly. Robert Staehle and his colleagues at the World Space Foundation have proposed the development of a lunar outpost using off-the-shelf technologies that could be put together quickly and inexpensively.

Staehle's "quick-and-dirty" base calls for the use of life-support systems built in the 1970s for America's first space station, Skylab, which would be sufficient to keep five people healthy on the lunar surface for up to a year.

The base would be built at one of the Moon's poles, where near-constant illumination would provide energy for rolls of solar power cells that could be unfurled and draped on the sides of nearby craters. A solar tower with a mast-like sheath of solar cells would be raised to capture energy for the short periods when the main panels would be in shadow. As Staehle describes it, the mast would "emerge like a cobra from its basket, immediately rigid as it unravels, raised by a motor-driven crank."

But Staehle—whose team drew its inspiration from the first winter outpost in Antarctica established in 1899—emphasizes that his vision of a Moonbase was developed more to make a point than to advance a specific proposal.

"Some people say it would not be possible to get people back to the Moon in ten years, but I think a statement like that is absurd," he says. "We committed to go [to the Moon] in 1961 and got there in 1969. To say we can't do it again [in the same period of time] makes no sense to me."

Considering the high expectations raised 20 years ago, a lunar base should be the least of our dreams to be realized by the time Apollo's fortieth anniversary comes around. □

Miles Weiss and Greg Freiherr are freelancers in Silver Spring, Maryland who write frequently on medical and space technology.

ISSUED PRECISELY 20 YEARS AFTER THE APOLLO 11 LANDING

Official announcement of the

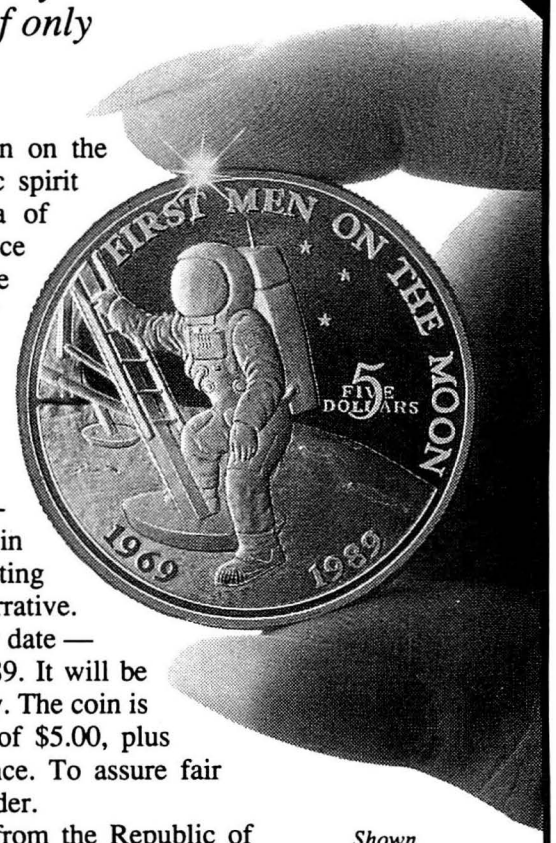
FIRST MEN ON THE MOON $5 COMMEMORATIVE COIN

An affirmation of American ingenuity and courage, available at the face value of only $5.00. Now you can hold a piece of history in your hand.

Twenty years ago, America landed the first men on the moon. And this year, the self-confident and heroic spirit that put America's flag on the moon's Sea of Tranquillity will be officially marked with the issuance of the First Men on the Moon $5 Commemorative Coin. This legal tender coin is being issued by the Republic of the Marshall Islands, where America has an important space tracking station.

The coin dramatically depicts the triumphant moment when American astronauts became the first men on the moon. About the same diameter as a Silver Dollar, the coin is even thicker — and painstakingly minted in a brilliant uncirculated finish. Each coin is protectively encased, after passing exacting minting standards, and is accompanied by an authoritative narrative.

This historic coin will be issued on the anniversary date — July 20, 1989 — and it will be minted only in 1989. It will be available only for a short time and in limited quantity. The coin is offered without any premium over its face value of $5.00, plus $1.00 per coin for shipping, handling, and insurance. To assure fair distribution, there is a strict limit of five coins per order.



Shown enlarged. Actual diameter: 1 ½"

Order promptly — for yourself or as a gift — from the Republic of the Marshall Islands Coin Fulfillment Center, One Unicover Center, Cheyenne, Wyoming 82008-1989. Phone TOLL-FREE 1-800-722-7121 from anywhere in the U.S. and Canada. All orders are subject to limitation and acceptance. *Satisfaction guaranteed.*

REPUBLIC OF THE MARSHALL ISLANDS COIN FULFILLMENT CENTER
One Unicover Center • Cheyenne, Wyoming 82008-1989

QTY

Please accept my order as shown. Total price of $6.00 per coin includes shipping, handling, and insurance. Limit: 5.

Total amount of order: $_____.

❑ I enclose full payment by check or money order payable to Coin Fulfillment Center.

❑ Charge my order to
❑ American Express ❑ Visa
❑ MasterCard ❑ Diners Club

CARD NO. _____ EXP. DATE _____

SIGNATURE _____ (All orders subject to acceptance)

MR./MRS./MISS/MS. _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

ORDER BY TOLL-FREE TELEPHONE, CALL

1-800-722-7121

from anywhere in the U.S. and Canada.
When calling, please mention this code: **BAEN-L201**

Your order will be acknowledged. Allow until September 20, 1989 for shipment.
©1989 RMI



HAWKER AEROSPACE
SPACE & AVIATION
COFFEE MUGS & BEER STEINS!
Porcelain, large 14 oz. capacity mug and 24 oz stein; Back describes performance and mission. Look inside after your last sip.
NEW! B-2 Stealth Bomber
Space Station Freedom
Also:

Space Shuttle	F-14 Tomcat
SR-71 Blackbird	F-18 Hornet
F-15 Eagle	F-16 Falcon
F-4 Phantom	A-10 Thunderbolt
AV8B Harrier	B-1B Bomber
F-111 Fighter-Bomber	UH-1 Huey
UH-60 Black Hawk	F-5 Tiger
UH-64 Apache	C-130 Hercules
C-141 Starlifter	C-5 Galaxy
AH-64 Apache	B52- Stratofortress
AH-1 Cobra	KC-135 Stratotanker
KC-10 Extender	STS-Mission 30
CH-47 Chinook	

Mugs-$6.95 + $3 shipping per mug or set of any 6, $35.00 + $6 shipping
Steins-$13.95 + $4 shipping per mug or set of any 4, $45.00 + $8 shipping. Calif. residents add sales tax.
HAWKER AEROSPACE
16731 Bartlett Lane Ste. 1, Huntington Beach, CA 92647 (714) 890-9621
Call for free catalog.

The Future As It Was

continued from page 23

Mars Project) for the *Collier's* article. He envisioned a 31-month mission, including a 15-month stay on the planet itself, involving the same number of ships and crew members. Perhaps this was a kinder, gentler von Braun, for he devoted as much space to the potential physical and psychological problems of Marsbound astronauts as to the hardware itself.

Ah, but what hardware he conceived! Each Mars ship was to weigh more than 4000 *tons* (the size of a post-war destroyer), most of it in fuel tanks and propellant for the 700-million-mile round trip. Three winged spaceplanes derived from von Braun's and Ley's Earth-orbit shuttlecraft went along for the ride; they would be assembled as the expedition circled Mars, then flown down to a landing on one of the planet's polar caps.

Von Braun mapped out the trip based on known technology, but even he admitted that he was being conservative with his genius. "Scientific advances," the good doctor wrote, "will undoubtedly make obsolete many of the engineering concepts...."

Von Braun's lucid and patient explanations of space science and applications, coupled with Bonestell's futuristic artwork, had raised public consciousness about the possibility of real, near-term human voyages into the cosmos. But it was the gee-whiz medium of television that helped turn America's fascination with space into an honest-to-goodness craze.

The earliest efforts to bring the sights and sounds of space to the tube were simply "talking heads" evolutions of classroom lectures. One such pioneer, science teacher John Sternig, developed and starred in a 13-week series of educational space shows on Chicago station WBKB in 1953. Lacking ready-made visual aids, Sternig himself constructed models and made drawings to illustrate the fundamentals of space travel.

"We attempted certain kinds of special effects, too," Sternig recalls, "like attaching a magnet behind a cutout of a rocket and moving it so that it appeared to fly against the background of the Earth, Moon and planets."

It remained for master showman Walt Disney to create the fusion of art and science that made "space" a household world in the 1950s. Disney had realized the potential of television long

INVEST IN AMERICA'S FUTURE IN SPACE—
E-PRIME AEROSPACE

Call Gregory M. Sprigg or C.J. Oropeza
1-800-525-4348
FIRST EAGLE, INC.
Colorado Residents call (303) 694-0088

This announcement is neither an offer to sell nor a solicitation of an offer to buy any of these securities. The offer is made only by the Prospectus, copies of which may be obtained in any state as may lawfully offer these securities in compliance with the securities laws of such states.

TO CELEBRATE THE 20TH ANNIVERSARY OF AMERICA'S FIRST WALK ON THE MOON... THE APOLLO 11 LUNAR LANDING.

WRITE WITH THE PEN THAT WROTE ON THE MOON!

When you're 186,000 miles from the nearest store, you need a pen you can depend on. That's why NASA chose the Fisher Space Pen to go to the moon.
It didn't run out of ink because its Thixotropic ink is hermetically sealed, and will write 3 times longer than ordinary pens. Guaranteed not to leak, blob, or skip ...while writing in the extreme temperatures of outer space, (from -500° to +400°F), under water, through grease, on glossy surfaces—even upside down... for at least one full year.

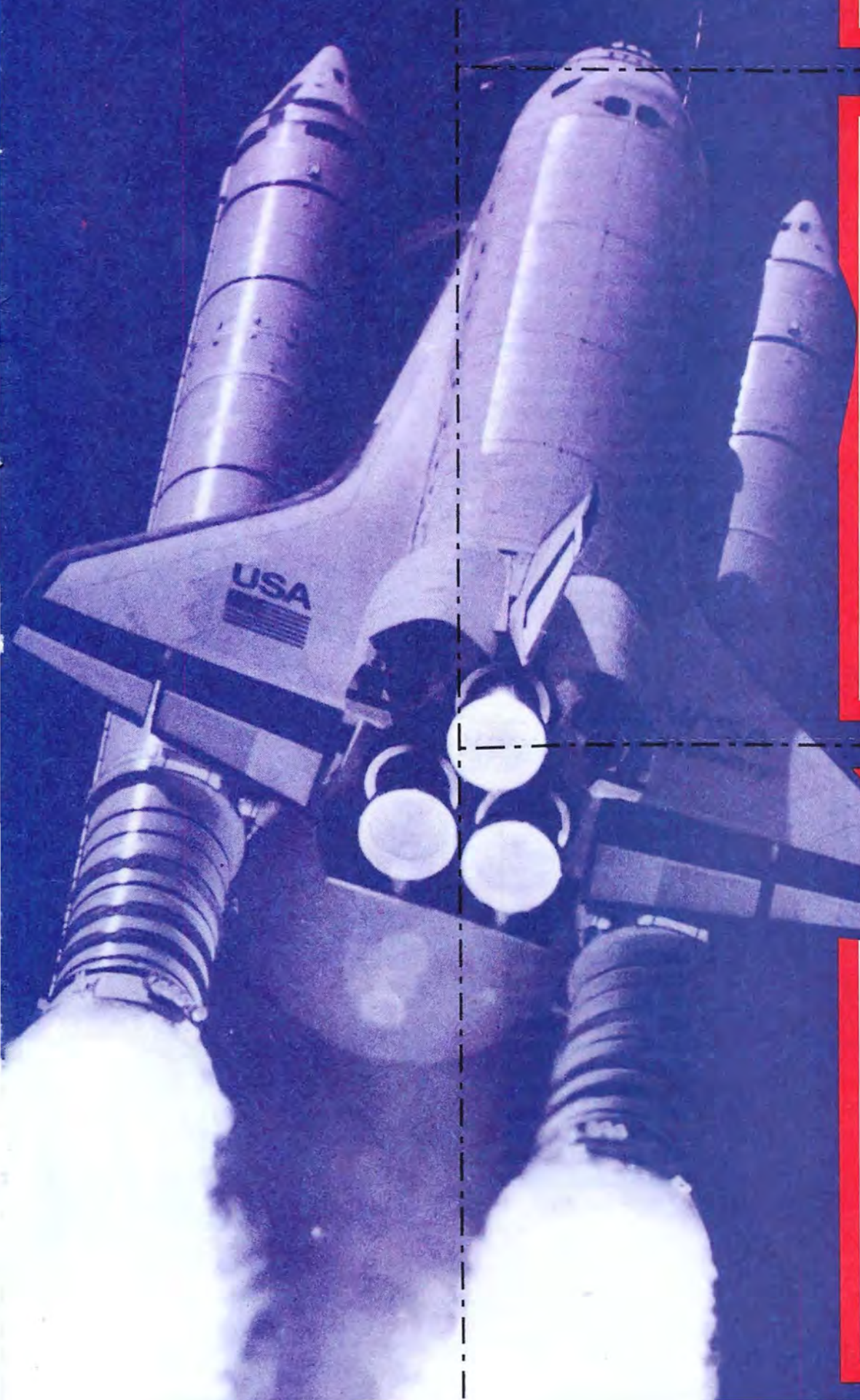


Don't miss out on this limited edition, solid bronze coin and gold-plated pen set, beautifully presented in a black velour gift box.
ONLY $19.95
+ $1.50 POSTAGE

Send check or money order to:
FINAL FRONTIER PEN
2400 FOSHAY TOWER
MINNEAPOLIS, MN 55402
TO ORDER BY PHONE WITH CREDIT CARD: (612) 332-3001
FOREIGN ORDERS ADD $2

SUBSCRIBE NOW TO FINAL FRONTIER

IT'S THE NEXT BEST THING TO BEING THERE!



LAUNCH YOURSELF INTO ORBIT!

FINAL FRONTIER costs $21.00 a year if you buy it on the newsstand. But if you send in this card, you'll receive FINAL FRONTIER for only $14.95 per year (six issues). That's a savings of 29% off the newsstand price.

Name

Address Apt. #

City State Zip BSH9S

☐ Payment enclosed ☐ Bill me

Please allow 4-8 weeks delivery. Canadian rate $19.95, all other countries $23.95. Payment in U.S. currency must accompany all foreign orders.

LAUNCH A FRIEND INTO ORBIT!

Enter a one-year (six issues) gift subscription of FINAL FRONTIER in my friends' name for only $14.95, a savings of 29% off the newsstand price. We'll send them a card announcing your gift.

Send gift to:

Address Apt. #

City State Zip

Gift sent from: Name

Address Apt. #

City State Zip BSH9S

☐ Payment enclosed ☐ Bill me

Please allow 4-8 weeks delivery. Canadian rate $19.95, all other countries $23.95. Payment in U.S. currency must accompany all foreign orders.

LAUNCH YOURSELF INTO ORBIT!

FINAL FRONTIER costs $21.00 a year if you buy it on the newsstand. But if you send in this card, you'll receive FINAL FRONTIER for only $14.95 per year (six issues). That's a savings of 29% off the newsstand price.

Name

Address Apt. #

City State Zip BSH9S

☐ Payment enclosed ☐ Bill me

Please allow 4-8 weeks delivery. Canadian rate $19.95, all other countries $23.95. Payment in U.S. currency must accompany all foreign orders.

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 89016 ESCONDIDO, CA

POSTAGE WILL BE PAID BY ADDRESSEE

FINAL FRONTIER
P.O. Box 3803
Escondido, CA 92025-9561

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 89016 ESCONDIDO, CA

POSTAGE WILL BE PAID BY ADDRESSEE

FINAL FRONTIER
P.O. Box 3803
Escondido, CA 92025-9561

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 89016 ESCONDIDO, CA

POSTAGE WILL BE PAID BY ADDRESSEE

FINAL FRONTIER
P.O. Box 3803
Escondido, CA 92025-9561

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BREAK-THROUGHS

Will the predictions of a fiercely adventurous new age of space exploration be borne out? Read about the great advancements as they happen in every issue.

▼ ▼ ▼

VISIONARIES

Meet the unsung seers of space travel—designers, engineers, astronauts, discover their ambitions, fears and aspirations.

▼ ▼ ▼

GIFTS

FINAL FRONTIER makes an ideal gift. Your thoughtfulness will be remembered all year long.

▼ ▼ ▼

ONE YEAR PRICE COMPARISON

	PRICE PER COPY	PRICE PER YEAR
NEWSSTAND	$3.50	$21.00
SUBSCRIPTION	$2.49	$14.95

▼ ▼ ▼

UNCONDITIONAL GUARANTEE

If at any time you are not satisfied with FINAL FRONTIER, you are entitled to an unquestioned refund for any unmailed copies.

▼ ▼ ▼

If order cards have been removed, send your name, address and $14.95 to:

FINAL FRONTIER
P.O. Box 3803
Escondido, CA 92025

Please allow 4-8 weeks delivery. Canadian rate $19.95, all other countries $23.95. Payment in U.S. currency must accompany all foreign orders.

before many of his movie contemporaries, coming up with the *Disneyland* show on the American Broadcasting Company in 1954, at least partly to drum up interest for his theme park of the same name in Anaheim, California.

The format of the Disney telecasts mirrored the park's layout of four "lands": Fantasyland, Adventureland, Frontierland and Tomorrowland. Disney knew that animated and live-action theatrical features would supply hours of programming for the first two areas, and his planned productions of "Davy Crockett" would fill the bill for Frontierland. When it came to Tomorrowland, however, he feared a famine of material.

Disney turned to a trusted staff member, Ward Kimball, for help. Kimball was best known for his work on animated films such as *Pinocchio* and *Cinderella*, but he was an avid space enthusiast as well. He and Chesley Bonestell were good friends and amateur astronomers, often visiting each others' homes to stargaze through telescopes.

Kimball had followed the *Collier's* features closely, and suggested that Disney adapt the magazine series as a possible Tomorrowland segment. After receiving Disney's eager approval and a "blank check" (something Disney had *never* done), Kimball hired Ley, von Braun and Heinz Haber—all *Collier's* veterans—as advisors for the program, tentatively titled "Rockets and Space."

Kimball remembers that von Braun jumped at the opportunity to reach the vast, ever-growing TV audience: "Look, put yourself back at that time. Nobody believed this stuff [space travel] would work," he says. "Von Braun said it was his chance to reach *millions* of people, rather than thousands. He knew there were skeptics in the military, and that his fellow rocket scientists in Russia were working on the same things."

It became apparent to Kimball and his production team that there was actually enough material for three shows. They eventually decided that the first segment should concentrate on a history of rocketry and the problems associated with human spaceflight, and that a title change—to "Man in Space"—was in order.

The program, shot in color but televised in glorious black-and-white, debuted on March 9, 1955. Disney himself prefaced the show, intoning in his fatherly yet friendly voice that "one of man's oldest dreams has been the desire for space travel." Kimball's script started with a short primer on the development of rockets from ancient to modern times, then continued with

SCALE THE MARTIAN MOUNTAINS!

FLY THROUGH THE CITY OF THE ANGELS!

HAVE A CLOSE ENCOUNTER WITH MIRANDA! (The moon of Uranus, that is.)

IN THIS NEWLY RELEASED VIDEO PRESENTATION:

DIGITAL LANDSCAPE:

...A VIEW FROM SPACE.

Created at NASA's famous Jet Propulsion Laboratory, the sequences in *Digital Landscape* are stunning examples of the state of the art in remote imagery, image enhancement, and computer graphics animation, including:

* **Earth: The Movie - A circumnavigation of the world, from above the clouds to the surface of the ocean.**
* **Mars: The Movie - A visit to the deepest valleys and the highest peaks on the Martian landscape.**
* **Miranda: - an exploration of the most geologically mysterious moon of Uranus.**
* **LA: The Movie - a high speed tour of the Los Angeles basin and the surrounding mountains.**

These sequences were produced from actual remote photographs from the Landsat satellite and the Viking and Voyager spacecrafts.

The photo images were specially enhanced, transformed into a 3D computer database, and used to create these beautiful simulated journeys.

Order Now. Only **$19.95**
plus $3.00 Postage and Handling

Send Check or Money Order to:

Video Publishing Group, Inc.
5055 NW 159th Street
Miami, Florida 33014

Specify VHS or BETA

A VPG Video Publishing Group **Video Publication**

"The Eagle Has Landed!"

JULY 20, 1989 IS THE 20TH ANNIVERSARY OF MAN'S FIRST LANDING ON THE MOON.



To commemorate this historic event, we are offering high quality photographic and lithographic prints of the original painting of the Apollo 11 design. This insignia was worn by the Apollo 11 crew on their first lunar landing mission. The painting was autographed, in 1969, by astronauts Neil Armstrong, Michael Collins and Buzz Aldrin. These are the only prints available showing the astronauts' signature.

Both the photographic and lithographic prints are full color, signed and numbered by the artist, Jim Cooper, and are the same size as the original, 18 x 18 in. Photographic prints are $65 each, and lithographs are $25 each, including shipping and tax.

The Apollo 11 design is on the reverse side of both the Suzan B. Anthony and Eisenhower dollars.

Send check or money order to:

COOPER GRAPHICS
P.O. Box 271364
Houston, Tx. 77277
Phone: 713-984-2123

DISCOVER THE HORIZONS OF SPACE







photo credits: NASA

Capture the most breathtaking and dynamic moments of Space Exploration with NASA photographs and Space Art reproduced in high-quality, custom color photographic prints



- **MERCURY**
- **GEMINI**
- **APOLLO**
- **SHUTTLE**
- **Impressive Gifts**
- **Great Corporate Promotions**
- **Beautiful in your home or office**
- **Mounting/matting & laminating**
- **Custom Sizes • Quantity Discounts**
- **Standard sizes • 11x14 • 16x20 • 20x24**

for *FREE COLOR BROCHURE*

***Call:* 1-800-444-1135**

(9 am to 5 pm, Monday - Friday, CST) in Houston call: (713) 333-3921

or write: **Horizon Discovery Group, Inc.**
18333 Egret Bay Blvd., #300, Houston, TX 77058

30-DAY MONEY BACK GUARANTEE
Visa • MasterCard
American Express

Heinz Haber's overview of the human considerations in space travel (illustrated by a sad-sack cartoon character dubbed "Homo Sapiens Extraterrestrialis"). Finally, a dapper von Braun stepped up to a detailed rocket model for the show's climax: an animated trek into orbit by a crew of astronauts, covering all the bases from launch to landing.

The parallels with the real thing are striking: 25 years before Columbia's first flight, Kimball's animators translated von Braun's inspiration into a remarkable approximation of a space shuttle rollout, complete with Vehicle Assembly Building and mobile launch crawler. And the fire and debris as each stage separates are eerily reminiscent of movie scenes returned from the early Apollo flights.

The second production, "Man and the Moon," premiered during *Disneyland's* 1956 season. Again directed by Ward Kimball, the show revolved around construction of a "space wheel" by astronauts in "bottle suits," and a subsequent first voyage around the Moon.

In a break with the first program, Kimball elected to use live action to depict the lunar mission. He and his co-writers also tried to spice up the script with a little melodrama; the crew had to cope with a meteor puncture, and they got a tantalizing glimpse of a ruined city as their flares exploded on the hidden side of the Moon.

"Von Braun didn't want to do that stuff," Kimball says of the allusion to previous lunar visitors. "I said, 'Can't we do *some* little thing, some suggestion of architectural formations?' Von Braun finally said okay—but that he wouldn't underwrite it."

Kimball also reminisces about the day when he tacked up a newspaper story speculating about possible Russian plans to fly to the Moon: "Von Braun read it—very slowly—then just stood there for the longest time. Finally he turned to me and said in his German-English accent 'Well, Waad—*we'd* better get going!'"

Just as in the *Collier's* series, Mars was to be the *piece de resistance* of the Disney shows. At von Braun's suggestion, Kimball brought in two more experts to flesh out the script. E.C. Slipher of Arizona's Lowell Observatory was recognized as an expert on Martian planetology and possible forms of life. Physicist Ernst Stuhlinger was an old crony of von Braun's, and an authority on the applications of atomic energy to space flight.

Night after night, Stuhlinger and von Braun hammered out designs for a fleet of umbrella-shaped piloted spacecraft

for the "Mars and Beyond" segment. It was a drill strangely familiar to Ward Kimball. "Those 'jam sessions' with Stuhlinger were just like the ones Walt used to have with us," he remembers fondly. "I guess it's the same in any creative process."

By the time "Mars and Beyond" aired in December 1957, the world had been turned upside-down by the Soviet Union's orbiting of the first two Sputniks. Still the show was a hit; it was so futuristic that the audience didn't identify with American's contemporary embarrrassment. It also took a lighthearted look at Mars, using whimsical animation to illustrate what was then known of the Red Planet's topography, weather and possible inhabitants.

Just two days after "Mars and Beyond" appeared, America's first feeble attempt to orbit a Vanguard satellite exploded ignominiously on the launch pad. Von Braun was summoned to rescue the nation's prestige with our first successful satellite, Explorer 1, and the *real* race for space with those haughty Russians was on.

It was the end of an era, sort of. Americans would still dream of rocketing around Earth and zooming off to the planets, but our outlook became more immediate, our plans more pragmatic. It was no longer a question of how to do things "best"; we wanted to do things "first," and to hell with that pesky nuisance called *imagination*.

Wernher von Braun, Willy Ley, Chesley Bonestell and that whole starship crew back in the 'fifties knew that imagination and dreaming were just the starting point. It was second nature to them. It was, simply, how you got things done.

Maybe someday we'll catch up with them.... □



Do you get the feeling that we're just going around in circles?



The CH1S—
The Contemporary Astronaut Pen and Pencil Set

Fisher Space Pens are the only pens accepted by NASA for use on manned space flights. The Astronaut pen has made many smooth trips around the world and to the moon. Writes at any angle...even upside down, and under water! All metal construction, flight button mechanism. Now available with matching .5mm pencil.

fisher
PEN COMPANY
743 Circle Ave.
Forest Park, IL 60130

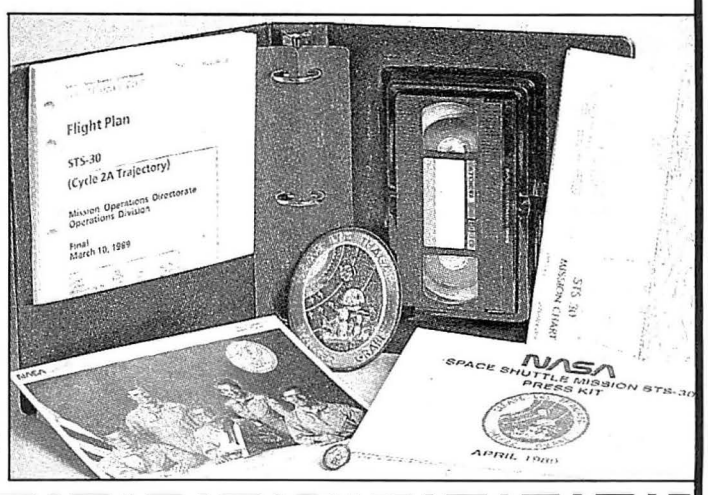
ALL ABOARD

STS 30: MAGELLAN SETS SAIL FOR VENUS

Introducing Final Frontier's new shuttle mission club. Reserve your seat on our first voyage! Hurry, supplies are limited!

You Receive:

- ▶ Mission Highlights Video (including post mission conference)
- ▶ Press Kit
- ▶ Orbit Track Map
- ▶ Flight Plan
- ▶ Mission Patch
- ▶ Collectors Pin
- ▶ Crew Photo
- ▶ Binder for convenient storage



Just Fill Out This Coupon & Return To: Final Frontier Shuttle Club
2400 Foshay Tower, Minneapolis, MN 55402

or CALL (612)) 332-3001 for fast delivery.

☐ ***YES!*** Rush me my STS 30 Shuttle Mission Club Kit for only $49.95 + $3.00 S/H.

Name _____ (please print)

Address _____

City _____ State _____ Zip _____

Daytime Phone _____

METHOD of PAYMENT

☐ Check/Money Order ☐ Visa ☐ M/C ☐ AMEX

Credit Card No. _____ Exp. Date _____

Signature _____

Call for overnight delivery price. For Canadian surface shipment double S/H, overseas triple.

Handbook for Aerospace Education

The "How To" book on aerospace education for schools, communities, and Young Astronaut Programs. This Handbook provides a wealth of knowledge including start-up and curriculum ideas with over 270 listings for resource materials. Introduction by Astronaut Charles Walker, NSS. Preface by Richard MacLeod, Space Foundation.

aedp

Aerospace Educational Development Program, 6991 S. Madison Way, Littleton, CO 80122

$8.95 plus $2.05 postage/handling.

ISBN 0-9620988-0-9

HELIOS PLANETARIUMS

A Motorized Model of our Planetary System & much more



- Converts into other models
- Dozens of attachments
- Illuminated Sun
- Complete Instruction Book

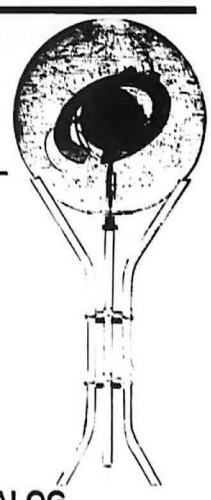
ONLY $595 Shipping Extra

Allow 4-8 Weeks Delivery on Helios

STARSHIP EARTH

Celestial Spheres w / inst.

16" desktop	$240 ppd
16" floorstand	$325 ppd
30" w/stand	$1200 +ship.



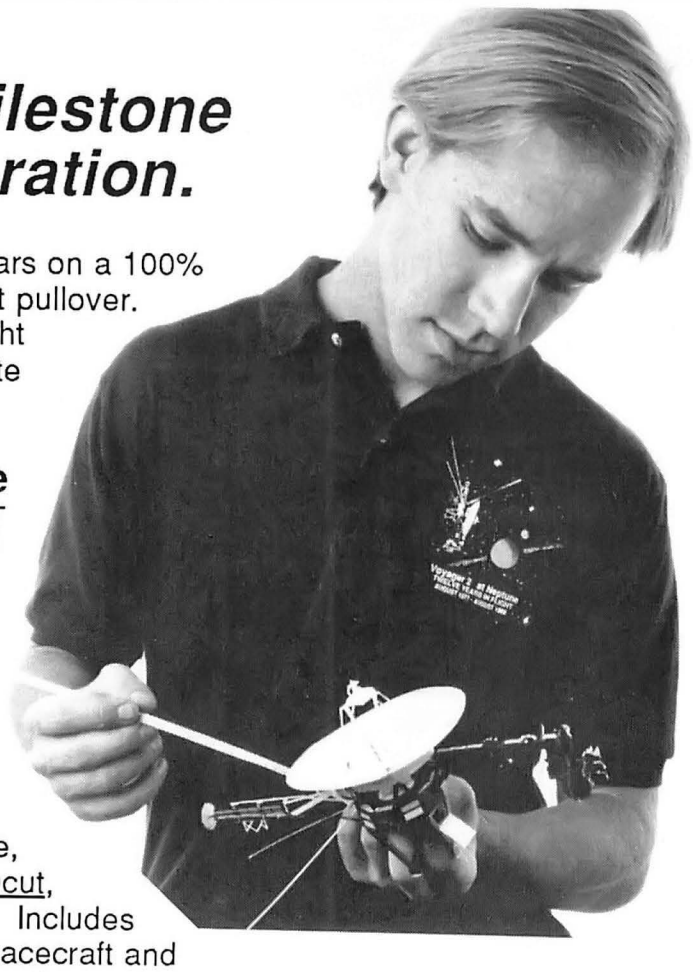
100's of Unique Products
1000's of Astronomy Slides
Hemispheres & Planispheres
Overheads w/ moving parts
Table-top Orreries
Computer Software
Games & Charts
Videos & Books
Sundials & Astrolabes
Solar Energy Experiments
Globes of all Kinds
& Much More!

FREE CATALOG
VISA/MC Accepted
FREE Gifts with Order

Guaranteed Quality in Educational Products

(719) 495-3828
BLACK FOREST OBSERVATORY
A Nonprofit Independent Educational Corporation
12815 Porcupine Lane, Colorado Springs, CO 80908

Celebrate a milestone in space exploration.



Voyager appears among the stars on a 100% combed-cotton, top-quality sport pullover. Neptune is deep blue, with a bright yellow- gold satellite Triton. White lettering reads:

Voyager 2 at Neptune
TWELVE YEARS IN FLIGHT
AUGUST, 1977 - AUGUST, 1989

Royal blue or darker navy. **$30**
Also available on heavy 100% cotton navy blue T-shirt. **$14**

Specify S, M, L, XL. Add $2/shirt for shipping in U.S.A.; $3 Canada & Mexico; $6 other countries.

Voyager Model is an accurate, educational kit made of laser-precut, lithographed heavyweight paper. Includes detailed information about the spacecraft and its mission. With assembly instructions. **$14**
Postpaid in U.S.A., Canada, and Mexico. Other countries, add $2.00.

California residents add 6.5% tax. Orders from outside the U.S. must be via international money order or check from a U.S Bank. Send order with check or money order to:

SCI / Space Craft International
953 East Colorado Blvd., No. 201 / Pasadena, California 91106-2391
Look for Space Craft™ products at your favorite planetarium. Made in U.S.A.

Space Station

continued from page 19

nauts will be observing and controlling them from these windowed lookout posts.

Robot "repairmen" will crawl along Freedom's structural girders or fly free in space, while human operators keep a watchful eye. Concern about nearby objects—perhaps dropped by accident, perhaps approaching the station for unknown reasons— will be lessened by the crew's ability to keep such objects in sight, especially since the station will have no radar or other automatic sensors. And when a visiting space shuttle maneuvers to dock with the station, astronauts will be able to verify that the orbiter is properly aligned and locked with Freedom's docking port.

Requests for Earth observations—either of atmospheric events like hurricanes or events on the surface—will be easy to satisfy from the cupolas as well. Binoculars, maps and cameras most likely will be stored close by, perhaps in a locker beside the entrance to the node. One visual aid under consideration is a high-tech viewer that automatically determines the latitude and longitude of any place below it on the Earth's surface. Likewise, small telescopes and navigational aids would be stowed near to the star-side cupola.

When the cupolas aren't being used for operations, Freedom's astronaut crew undoubtedly will use them as a place to while away off-duty hours. "For us in orbit, visual observations replaced theatre and movies," recalled cosmonaut Anatoliy Berezovoy, who spent seven months aboard the Salyut 7 station. Soviet spacefarers are inveterate Earth-watchers: In planned and recreational viewing, they spend two to three hours per day at their windows.

The space shuttle orbiter's flight deck was a kind of victory for space sightseers, with its four forward windows and two overhead windows that provide a 180-degree sweep of the visual field. In orbit, the spaceplane usually flies with its belly to deep space, and astronauts are thrilled to discover that the pilot's windows allow a spectacular view of Earth.

On his first shuttle flight in 1983, astronaut Norm Thagard later told the press, "I turned myself upside down over in the right hand seat, and you could just sit there and look at the world go by. It was like being in the gondola of a dirigible, only this dirigible was 160 miles up in the sky." Oceanographer Paul Scully-Power practically never left the front cockpit during his week-long

flight the following year: "It's by far the best way of looking at the Earth," he later reported.

Even compared to the shuttle, Freedom's cupolas will be an Earth-gazer's paradise with their 360-degree view. But space is a hostile environment, and plumes from small shuttle rocket engines spray nasty chemicals on window panes, dirtying the view. Space dust scratches and erodes the surface of the panes. The windows' own sealant glues might creep onto the outside, and even smudges from the astronauts' hair and skin oils can smear the inside surfaces.

Attempts to clean the windows won't be simple, either. It's not that astronauts *won't* "do windows"—they *can't*. On America's first space walk a quarter of a century ago, the first orbital window-washer, Ed White, tried to wipe a smudge from Gemini 4's window and only made it worse. Later use of special pads and brushes brought only marginal improvement.

So Freedom's windows won't be washed—they'll be replaced. The design currently calls for four window "panes" per window. The thin outermost pane, the one that will absorb the most damage from micrometeorites and contamination from rocket fuel, is a "sacrificial pane" that will be replaced by spacewalking astronauts every year or so.

During the daylight portion of each orbit, most—but not all—of the space station will be visible from the cupolas, and blinds or shades may be needed to block out the Sun's brightness in order to read computer displays on the control panels. During the nighttime portion of the orbit, the station's structure will loom outside as a dark silhouette against the stars or the lights of bright cities, since Freedom will have no running lights of its own. A few lit windows from the living and working modules may be visible, along with headlights used by the robot manipulator for its TV cameras. The cupola's numerous computer displays will cast their own multicolored illumination, preventing astronauts' eyes from adapting fully to the dark.

The passing universe will appear very close from Freedom's cupolas—both to the eye and to the soul. NASA's plans call for unique engineering and scientific work to be conducted on the space station. But as a new human vantage point in orbit, the cupolas also will be a breeding ground for great thoughts and imaginations...all unplanned, all unpredictable. □

Alcestis Oberg's last article for Final Frontier *was on terraforming.*

Earth, Mars and Beyond

THE JPL TAPES

Take a unique tour of our universe. Explore the planets Earth, Mars and a moon of Uranus through the magic of JPL's computer generated animation.

Celebrating the launch of the Magellan space probe, this video adventure is available for only $29.95.

Call today to reserve your VHS or Beta flight.

Call 1-800-950-4565, Ext. 1483

THE VIDEO TAPE COMPANY

A WesternWorld Company



Relive America's Greatest Moment!

"Buzz Aldrin tells it all...in gripping detail he takes us along, minute by minute, from blast off to splash down."
—WALTER CRONKITE

"It is a rare privilege to read history from the man who made it." —TOM CLANCY

"A voyage that will probably be remembered as the sublime achievement of the 20th century. Buzz Aldrin was there!"
—STEPHEN COONTS

MEN FROM EARTH

Buzz Aldrin and Malcolm McConnell

With 16 pages of photographs
Selection of the Book-of-the-Month Club

A BANTAM HARDCOVER

CLASSIFIEDS

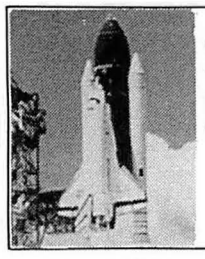
SPACE COLLECTIBLES

SERIOUS COLLECTORS!!
30-YEARS: INTERNATIONAL SPACE INSIGNIA PINS
AUTHENTIC Official designs, genuine cloisonne. SUPPLIER to KSC, JSC, Young Astronauts, Museums. EXCLUSIVE source: USSR, ESA, CANADA, JPL, CUSTOM Aerospace Projects.
PROTECT your collection with custom ALBUMS.
$2 for complete Pin/Patch catalog, deductible from order.
SPACECOM INTERNATIONAL, Box 7304-223F
N. Hollywood, CA 91603-7304
LIMITED EDITION – Apollo 11 Anniversary Pin – Reserve now!

COLLECTORS
PATCHES • TACS • DECALS • ETC
For Catalog Send $2.00 To:
Sky Patch Enterprises
P.O. Box 3339, Dept. F
Lompoc, CA 93438
Outside USA $3.00 US Currency

MADE IN SPACE ABOARD CHALLENGER DURING STS-6, CHALLENGER'S MAIDEN FLIGHT. "THE FIRST SPACE PRODUCT." $5.00 ppd includes certificate verifying authenticity. BYLINA, P.O. Box 25844, Colorado Springs, CO 80936

METEORITES
AVAILABLE TO ASTRONOMERS, SCHOOLS INSTITUTIONS AND PRIVATE COLLECTORS. STONES & IRON SPECIMENS. **LIMITED SUPPLY.**
ROBERT A. HAAG — METEORITES
Box 27527, Tucson, AZ 85726
— PLEASE SEND $2.00 FOR FULL COLOR CATALOG —
Refundable on first order



"Do You Believe in the Dream?"
Wear the Shuttle—Wear the Badge. Tie tacks, stickpins, brooches & keychains produced with laser sharp color photos. Send SASE for flyer to:
Des Postages
4529 S.W. Hamilton Terrace
Portland, OR 97201
DEALERS WANTED

LIMITED EDITION
1st Manned Lunar Landing
20th Anniversary Plate
Artfully etched in the center of an 8" commemorative glass plate. 100% Satisfaction Guaranteed. Reserve yours before Sept. 30. Send $32.50 to: Etch-N-Things Dept. MB, P.O. Box 268, Worthington, Ohio 43085. Also available at the Neil Armstrong Air & Space Museum, Wapakoneta, OH.

APOLLO 11 COMMEMORATIVE
SPECIAL 20th ANNIVERSARY
APOLLO 11 MISSION PATCH
Beautiful full embroidery patch of 11 vivid colors. Official 4" size with names and dates accented in gold metallic thread. Limited Collectors Edition (20,000). ONLY $7.50 ea. + P&H
Order No. APO506FF
VISA MasterCard
1989 Space Collectible Catalog $2 ppd. (refundable)
STAR REALM
Dept. AS • 7305 S. 85 Street • Omaha, NE 68128

METEORITES!
AUTHENTIC SPACE COLLECTIBLES
Display stands, space jewelry, books, photographs. Catalog $2. (Refundable)
BETHANY TRADING COMPANY
P.O. BOX 3726-F,
NEW HAVEN,
CT 06525
CATCH A FALLING STAR! SM
(203) 393-3395

SPACE SHUTTLE PROGRAM exciting color prints collection. For catalog and sample send $1.00 to SPACE COLLECTION, Box 701-F, Cape Canaveral, FL 32920

CLOTHING



SPACE & ASTRONOMY DESIGNS ON HEAVY-WEIGHT T-SHIRTS + SWEATS
CALL OR WRITE FOR FREE CATALOG
Caledonian Graphics,
Dept. F,
P.O. Box 875, Zephyrhills, Fl. 34283.
1-800-223-4607
CALEDONIAN GRAPHICS

BOOKS & PERIODICALS

SOVIET MILITARY SPACE CHALLENGE. Illustrated complete report, $15. STRATAGEM PUBLISHERS, Dept. A, 168 Northcliffe Dr., Winnipeg, Manitoba, Canada R2C 4J4

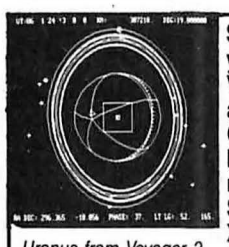
SPACE FRONTIERS. Journal of space history. Scale plans, modeling. $15/year, bimonthly. Free information and back issues list. SPACE FRONTIERS, PO Box 6488, Newport News, Virginia 23606

***Space Times* Journal**
Bold editorials, space sci-fi short stories, astronomy forecasting, astrophotography and investigative reporting. Finally - a political, non-partisan look at current issues on space.
Sample $2.00
Subscribe today - $10.00/6 issues
Space Times Journal
Suite 168, 33 University Sq., Madison, WI 53715

KEEP UP TO DATE WITH NASA USING YOUR COMPUTER. **"NASA SPACELINK USERS GUIDE."** Send $8.00 check to: CORE, P.O. Box 25594, Fresno, CA 93729

FACES ON MARS? Yes! Latest (1988) digital photo-analysis NASA data. New faces, pyramids found. Book: 137 pp, 80 photos. $15. MARS RESEARCH PROJECT, Dept F, Box 284, Glenn Dale, MD 20769

COMPUTERS & SOFTWARE



Uranus from Voyager 2

Simulate Voyager 2 at Neptune on your IBM PC or compatible! Plus Voyager 1 and 2 at Jupiter, Saturn, and Uranus, and Giotto at Halley's Comet. Fascinating program originally developed at JPL. $79 (California residents add 6.5% sales tax) plus $3 S&H, or write for **FREE** information.
XonTech, Inc., *6862 Hayvenhurst Av., Van Nuys, CA 91406 (818)787-7380*

HOBBIES & KITS

LASER PHASERS PLASMA
Plasma sabres, tesla coils, anti gravity, see in the dark, surveillance, force fields, personal protection etc. and many others. **CATALOG** of plans, parts, kits and assemblys send $1.00 to Amazing Concepts, Dept FF, PO Box 716, Amherst, NH 03031.

MISCELLANEOUS

WHO IS THIS GUY!



© **Sleep tight America-your Air Force is awake.**
THE ORIGINAL POSTER AND THE STORY BEHIND IT!
B&W POSTER UNFRAMED 17x22
$7.95 2 FOR $10.00
PHOTO COFFEE CUP PORCELAIN 12 OZ.
2 FOR $12.00 4 FOR $19.95
9" TEDDY BEAR W/PRINTED T-SHIRT
SLEEP TIGHT AMERICA YOUR BEAR FORCE IS AWAKE
$12.95 2 FOR $20.00
PHOTO KEY CHAIN 2 FOR $5.00
AMEX - VISA - MC - DISCV - MO - CK
CENTURY ASSOCIATES
P.O. BOX 461852, GARLAND, TX 75046
CREDIT CARD ORDERS CALL
1-800-274-1120
1-214-272-1120
ALL INCLUDES SHIPPING

ROCKETRY

ROCKETS! SPACESHIPS! Out-of-production, hard-to-find: model rocketry, plastic kits, plans, literature, space/SF collectibles. Catalog $1. ACME ROCKET COMPANY, Box 28283-FF39, Tempe, AZ 85285

VIDEOS

SPACE FLOWN MEMORABILIA & VIDEOS
ACTUAL SPACE FLOWN Articles along with actual APOLLO **CM & LM Hardware & Apollo Tracking Charts!!**
Over 40 1 Hr. Mission Videos containing over 60 MISSIONS.
Examples: Apollos 10 & 11, 12 & 13, 14 & 15, 16 & 17;
Plus all Shuttle Missions -- Only $19.95 each !!
Apollo / Shuttle Press Kits & Flight Plans available!!
STS 29 Press Kit (Info) $10.00 FLIGHT PLAN $20.00
AVD 767 St. Michaels Dr. Mitchellville, MD 20716

SPACE VIDEOTAPES
Quality NASA produced videotapes on Apollo-Lunar, Mercury, Gemini, Challenger, and unmanned probes Mariner, Voyager, and Viking
Write for our FREE illustrated catalog .
SPECTRUM Video, Dept. F
PO Box 3698, Ontario, CA 91761

INVENTIONS & IDEAS

300 UNCONVENTIONAL TECHNOLOGIES!
Suppressed, dormant, emerging Inventions & Discoveries! Antigravity! Telsa! Transmutations! Psychotronics! "Free Energy" Generators! Astounding Information Archives Catalog! Send $2: REXEL, Box 1258, Berkeley, CA 94701

PLANETARY MAPS

MARS ♂
THE NEXT FRONTIER

THE MARS MAP

Mars is the next frontier that will be explored by humans. Explore the Red Planet NOW with THE MARS MAP. This detailed shaded relief map shows the volcanoes, canyons and craters of this alien world. This multi-colored map at a scale of 1:25,000,000, is printed on a 35 x 37 inch sheet. Includes index and glossary. Shipped rolled.

For more information write
EXPLORATION USA Dept. FF
P.O Box 456 College Park, MD 20740

PHOTOGRAPHS

BEAUTIFUL SPACE SHUTTLE PHOTOGRAPHY – We have a wide variety of pictures at low prices. Write for free information: SPACE IMAGES, PO Box 58694-F, Houston, TX 77258

AEROSPACE

FLY IN SPACE
2,200kph, 20km high. See Shuttle Launch. Join A.E.S.A. Info $1.00.
GEYER
1501 Roosevelt - F-1 • Carteret, NJ 07008

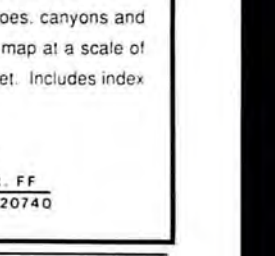
BUSINESS OPPORTUNITIES

GET PAID for mailing letters! $200.00 daily. Write: PAASE - N19, 161 Lincolnway, North Aurora, IL 60542

FREE DETAILS - Steady income from home in your spare time. Large $$ capital not required. Proven effective. SMACO, P.O. Box 25021, Minneapolis, MN 55458

EDUCATION

U.S. SPACE CAMP®
Register now for a week-long adventure into astronaut training and simulated Space Shuttle missions. Grades 4-6 for **U.S. SPACE CAMP** in Alabama and Florida. Grades 7-12 for **U.S. SPACE ACADEMY**. Write **U.S. SPACE CAMP '89**, Box 1680, Huntsville, AL 35807, or call toll-free **1-800-63-SPACE**, in Alabama call **205-837-3400.**



RATES & REQUIREMENTS

$55 minimum for 25 words. $1.75 each additional word. 10% discount if prepaid for 3 issues (same ad); 15% discount prepaid for 6 issues. Box or blind ad, $10 additional. Payment must accompany order. Non-commissionable. Include name, address & phone number. Advertising accepted at sole discretion of publisher

DISPLAY CLASSIFIEDS

$110 per column inch, one time; $95 per column inch, 3 times; $90 per column inch, 6 times. Column inch is 2¼ in. wide. Please design height in whole inches. Display ads can be designed for an additional charge.

DEADLINE & MAILING INSTRUCTIONS

Copy/mechanicals must be received 60 days prior to publication date (i.e. May 1 for July/Aug. issue). Mail copy or materials with payment to: FINAL FRONTIER MAGAZINE, Classified Dept., 2400 Foshay Tower, Minneapolis, MN 55402. For further information, call Stephen Martin at 612-332-3001.



Space Mission Patches From NASA's Contract Supplier.

A-B Emblem was the manufacturer of the original NASA patch. And since Apollo 12, A-B Emblem has been the sole supplier of patches to the astronauts, under exclusive contract with NASA.

Other manufacturers can say they supply patches to NASA, but this does not mean they make the space mission patches for the astronauts. Only A-B Emblem can say that. And now you can order direct.

The Latest In Space Patches.



STS-26



STS-27



Mercury, Gemini, Apollo-Soyuz, Skylab and European Space Agency patches also available.

A-B emblems are also available through Spaceport USA at Kennedy Space Center, and at NASA exchanges and museum gift shops throughout the world.

ORDER FORM

(All Shuttle/Apollo patches are 4", $4.95 ea. NASA insignia and all Mercury/Gemini patches are 3", $2.95 ea.)

Qty.	Stock #	Total Cost

Qty.	Package Prices:	Total cost
	Current Shuttle Series (27 patches) $108.65 Save $25.00	
	10 Most Recent Shuttle Patches $39.50 Save $10.00	
	Entire Apollo Series (12 patches) $49.50 Save $12.00	
	Entire Mercury Series (6 patches) $16.95	
	Entire Gemini Series (11 patches) $29.95	
	The Mission Data Booklet—gives complete summary of each NASA Mission. $3.95 ea. (free with purchase of $50 or more)	
	Sub-Total	
	NC Resident 3% Tax	
	Shipping/Handling	$2.00
	Total Order	

Call Toll Free. Have your VISA or MASTERCARD ready. Or send name, address, and check or money order to A-B Emblem, P.O. Box 82695, Weaverville, NC 28787.

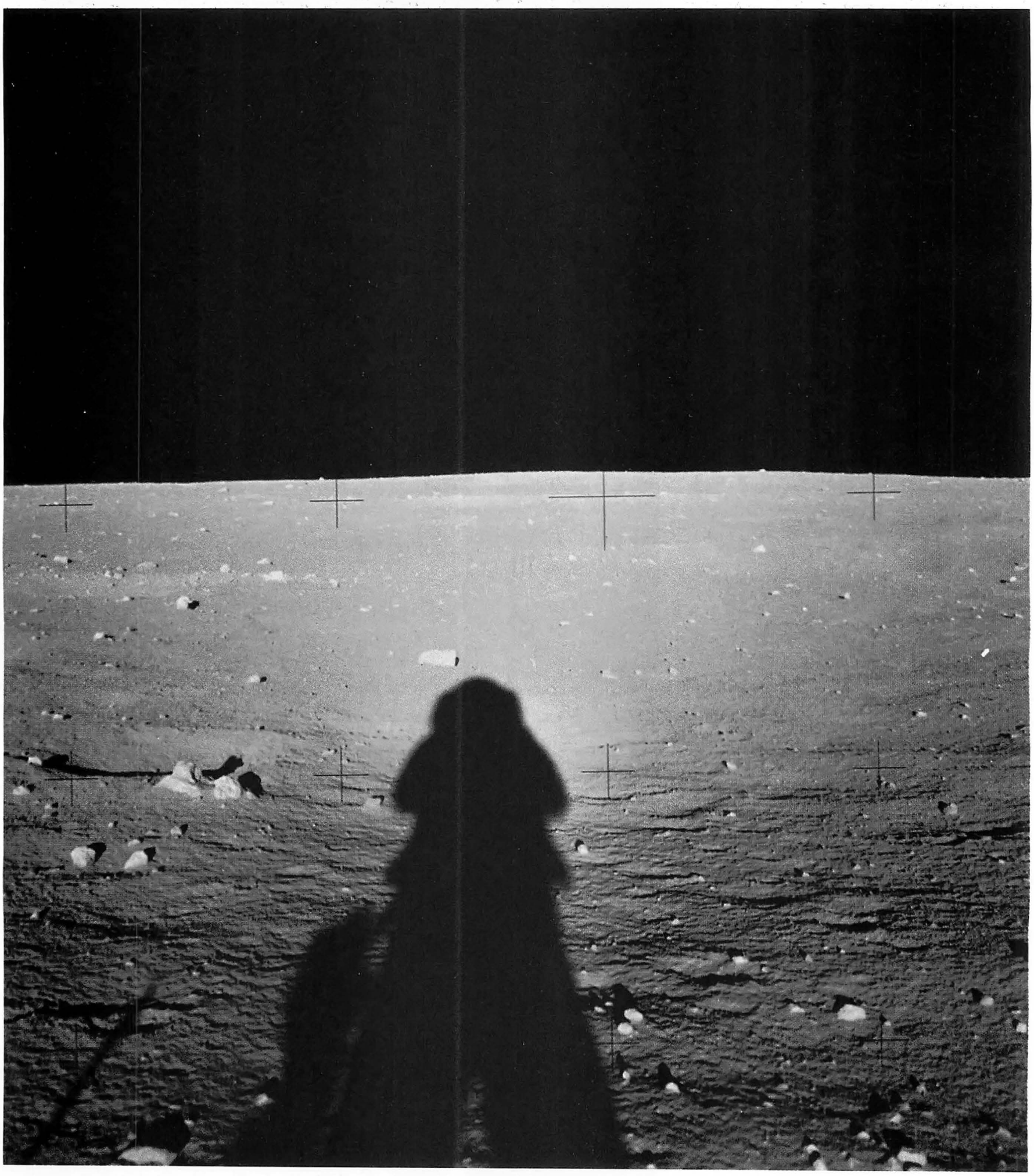
800/438-4285

A-B EMBLEM
DIVISION OF CONRAD INDUSTRIES, INC.
Weaverville, North Carolina 28787

DESTINATIONS

From the moment the first flint was
flaked, this landing was merely a matter of time.

W.H. Auden,
"Moon Landing" (1969)





CELESTRON'S

ULTIMA 8

SPEAKS FOR ITSELF

8″ Schmidt Cassegrain, 2032mm focal length (f/10), Swing-through fork mount with slow-motion controls; newly designed fork tines are twice the size of competing units, carry handles on forks, 2⅝″ diameter polar shaft cast into the base, 4″ diameter polar axis ball bearings, 7.54″ diameter Byers worm gear drive, high transmission special coatings on corrector and Starbright® enhanced reflectivity mirror coatings, totally cordless quartz-locked electronic drive system with rechargeable lead acid batteries. Batteries good for 500 charges — recharge from AC or DC. Large RA (8¾″) and DEC (5⅛″) circles, 8x50 finderscope with Polar alignment reticle for straight through or right angle viewing, 30mm Plossl eyepiece (68x) - 1¼″, 7mm Orthoscopic eyepiece (290x) - 1¼″, multicoated prism star diagonal - 1¼″, heavy duty wedge with latitude scale, deluxe latitude adjuster, bubble level, accessory tray, adjustable metal tripod with 2″ diameter rubber coated legs, NEW rugged foam fitted carrying case.



Deluxe Carrying Case

Constructed of high density polyethylene for rugged handling. Strength tested to over 500 pounds! Excellent low temperature characteristics. Foam fitted interior absorbs shocks and allows Ultima to be stored with finder in place.



Cordless Drive

Heavy duty industrial grade sealed lead-acid batteries. Can't be overcharged. NO EXCESS WIRES, CORDS, ETC. Byers drive is 30% larger in diameter with twice as many teeth as in competitive drives.



Fork Tines

Fork tines ribbed and cross-ribbed for maximum stiffness. Twice as large as competitive units. Includes carrying handles. Large DEC and RA circles for accuracy.



Digital Setting Circles (optional)

Pre-drilled for installation in a few minutes. Advanced model (shown) has over 8,000 objects in memory. No belts, pulleys or other complex hardware.

Tripod

Heavy rubber coated legs are vibration absorbent. Made of neoprene to withstand deterioration from UV rays and air pollutants. Legs clamp to one side so you won't hit your ankles when walking around the tripod. Sturdy rubber feet for rapid dampening.

Wedge

Extremely sturdy. Doubles as a shelf to hold accessories, etc.

Finderscope

Only finderscope on the market that can be used two ways—either straight-through or right angle.

Polar Shaft

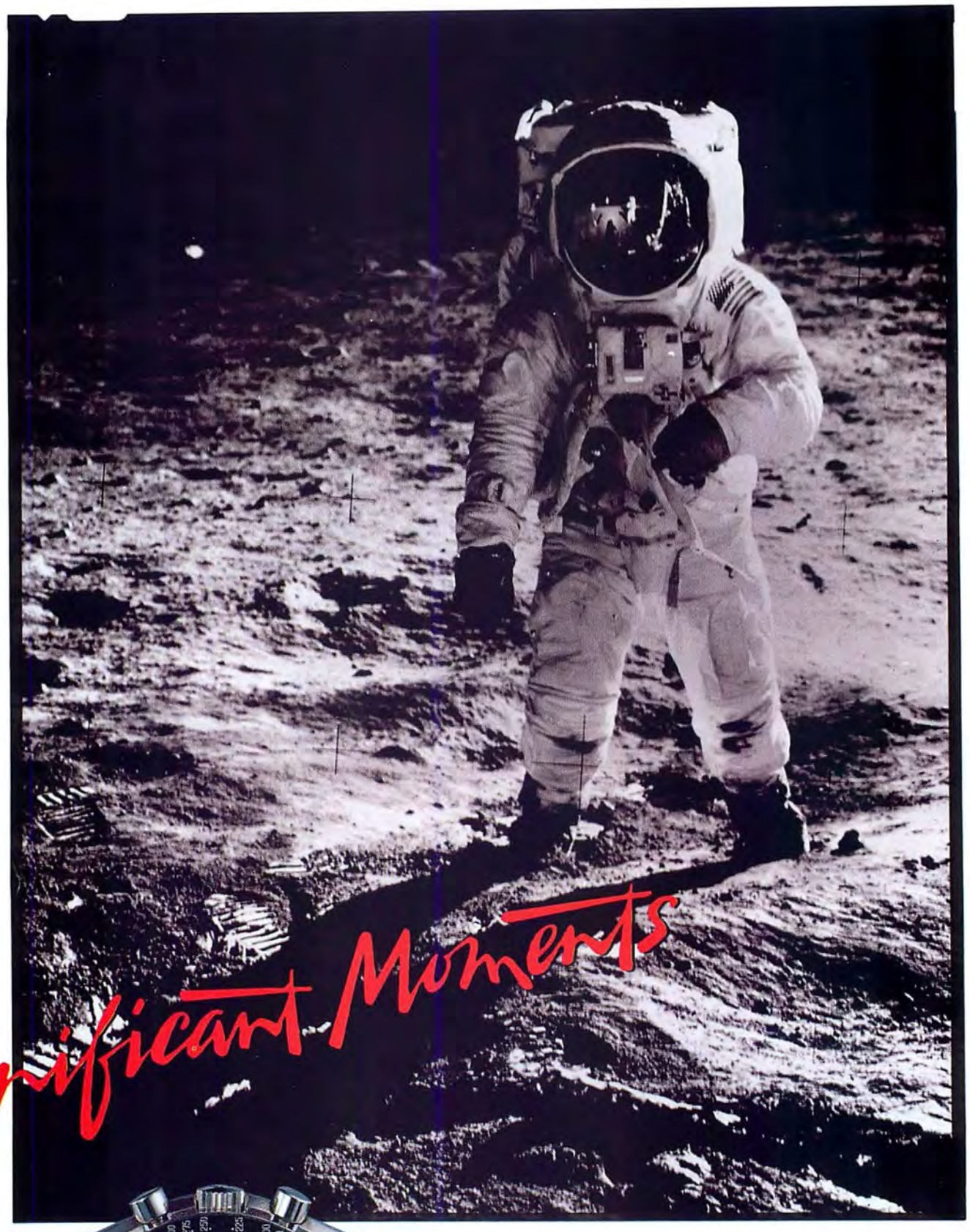
4″ diameter precision ball bearing supports polar axis. Drive base and polar housing are cast and machined as one integral unit for maximum stability.

Precision Optics

Diffraction limited. 1/10th wave accuracy. Starbright® coated for a higher level of total system transmission than any other competitive unit.

CELESTRON®
CELESTRON INTERNATIONAL
2835 Columbia Street • Torrance, CA 90503 (USA)
Telephone (213) 328-9560, (800) 421-1526 (Continental USA)

IT WAS A MOMENT OUT OF A DREAM. WHEN THE STEP OF A MAN TRANSFORMED THE HISTORY OF MANKIND. OMEGA. FOR THIS AND ALL OUR SIGNIFICANT MOMENTS.



Significant Moments



Registered Model

OMEGA ALWAYS MARKS SIGNIFICANT MOMENTS. AT THE OLYMPICS. IN THE SPACE PROGRAM. IN SIGNIFICANT LIVES LIKE YOURS. THE OMEGA SPEEDMASTER. FOR SPACE EXPLORATION. AND FOR YOU.

Ω OMEGA

MAYOR'S

Fine Jewelers Since 1910.

21 Stores in Central and South Florida. For the Mayor's store nearest you, please call 1-800-4-MAYOR'S.